Digital Transformation Group
Operational Technology

DESIGN STANDARD DS 42-01

VSAT Satellite Design

VERSION 2
REVISION 4

DECEMBER 2018

FOREWORD

Supervisory Control and Data Acquisition (SCADA) Design Standards are prepared to ensure that the Water Corporation's staff, consultants and contractors are informed as to the Water Corporation's design standards and recommended practices. Design standards are intended to promote uniformity so as to simplify design and drafting practice and have as their ultimate objective the provision of safe and functional plant at minimum whole of life cost.

The Water Corporation design standards and recommended practices described in this design standard have evolved over a number of years as a result of design and field experience and these have been investigated and documented.

Deviation, on a particular project, from the design standards and recommended practices may be permitted in special circumstances but only after consultation with and endorsement by the Principal SCADA Engineer in the Water Corporation's Operational Technology.

Users are invited to forward submissions for continuous improvement to the Principal SCADA Engineer who will consider these for incorporation into future revisions.

Manager, Operational Technology

This document is prepared without the assumption of a duty of care by the Water Corporation. The document is not intended to be nor should it be relied on as a substitute for professional engineering design expertise or any other professional advice.

It is the responsibility of the user to ensure they are using the current version of this document.

REVISION STATUS

The revision status of this standard is shown section by section below:

REVISION STATUS						
SECT.	**VER./ REV.**	**DATE**	**PAGES REVISED**	**REVISION DESCRIPTION (Section, Clause, Sub-Clause)**	**RVWD.**	**APRV.**
1	**1/1**	**31.03.14**	**All**	**New Version**	**JB**	**MH**
1	**2/0**	**15.07.16**	**All**	**New Version– major revision**	**JB**	**MH**
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DESIGN STANDARD DS 42-01
VSAT Satellite Design

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1 Preliminaries

1.1 Purpose

The purpose of this standard is to define VSAT (Very Small Aperture Terminal) satellite radio equipment installation requirements for the provision of reliable and robust SCADA (Supervisory Control and Data Acquisition) communications links for remote Water Corporation sites.

1.2 Scope

This standard shall apply to the design of SCADA VSAT BGAN (Broadband Global Area Network) satellite radio installations operating in the L-Band frequency range at Water Corporation sites.

For SCADA radio design standards, refer to DS 42-02 SCADA Radio Network Design.

This Standard refers to Water Corporation drawings contained in Drawing Planset JT17 – see References. The Drawings are referred to as the "JT17 Drawings" throughout this Standard. All SCADA equipment and installations shall conform to these Drawings, which shall constitute part of this Design Standard.

For SCADA radio design standards, refer to DS 42-02 SCADA Radio Network Design.

This standard complies with ACMA (Australian Communications and Media Authority) regulations that were applicable at the time of writing. The designer shall ensure compliance with future relevant changes to ACMA regulations.

1.3 Structure

The main body of this standard is divided into four separate portions. Sections 2, 3 and 4 respectively cover L-Band VSAT satellite radio design, external plant equipment, and earthing, bonding and lightning protection. Section 5 covers configuration and commissioning of the satellite radio system. Appendix A details the commissioning checklist and Appendix B details the earthing, bonding and lightning protection requirements.

1.4 References

ETSI	EG 200 053 V1.5.1 (2004-06) Electromagnetic compatibility and Radio spectrum Matters (ERM); Radio site engineering for radio equipment and systems
DS 42-03	Design Standard – SCADA Radio Equipment & Installation
DS 42-02	Design Standard – SCADA Radio Network Design
Planset JT17	Standards Drawings – Radio Communications
AS/CA S009	Installation requirements for customer cabling (wiring rules) http://www.commsalliance.com.au/__data/assets/pdf_file/0017/39203/S009_2013.pdf
F2012C00166	Radiocommunications (Communication with Space Object) Class Licence 1998 - 2012.02 http://www.comlaw.gov.au/Details/F2012C00166/674d7097-022c-43c0-bbc5-965824175 7f4

1.5 Definitions

ACMA	Australian Communications and Media Authority
AS/CA	Australian Standards/Communications Alliance Ltd
BER	Bit Error Rate
BGAN	Broadband Global Area Network
Corporation	Water Corporation (of Western Australia)
DC	Direct Current
ELV	Extra Low Voltage – a voltage not exceeding 42.4 VAC or 60 VDC
Feeder Cable	A cable that connects the antenna to the radio system

GLONASS	Global Navigation Satellite System – A space based satellite navigation system
GPS	Global Positioning System – A space based satellite navigation system
HV	High Voltage – a voltage exceeding 1000 VAC or 1500 VDC
IDU	Indoor Unit (i.e. satellite radio)
IEEE	Institute of Electrical and Electronics Engineers
INGAL EPS	An Australia's leading manufacturer of telecommunications poles, columns, and structures
IP	Internet Protocol – the principal communications protocol in the Internet protocol suite.
JT17 Drawings	Planset JT17 Standards Drawings – Radio Communications
kbps	Kilo bits per second, as applicable to data rates
LED	Light Emitting Diode
L-Band	Frequencies in the range 1 to 2 Ghz. (IEEE L Band definition)
LV	Low Voltage - a voltage exceeding ELV limits but not exceeding 1000 VAC or 1500 VDC
MRO	Murchison Radio Observatory
NAT	Network Address Translation – A method of translating private network addresses to public network addresses
ODU	Outdoor Unit
RX Sensitivity	Radio Receiver sensitivity
RTU	Remote Terminal Unit - A microprocessor-controlled electronic device that interfaces objects in the physical world to a distributed control system
SCADA	Supervisory Control And Data Acquisition
TE	Terminal Equipment – communications equipment at the end of a link
VAC	Voltage Alternating Current
VDC	Voltages Direct Current
VSAT	Very Small Aperture Terminal; a class of antennae used for satellite communications
WA	Western Australia

Table 1-1 Table of References

2 VSAT Satellite Radio Design

The following requirements shall apply to the design of all new and existing Water Corporation L-Band VSAT BGAN satellite SCADA radio systems.

2.1 Design Objectives

The primary design objective for L-Band VSAT BGAN satellite SCADA systems includes:

a) Achieve reliable satellite radio communications to the Water Corporation asset;

b) Minimise the cost and need for antenna support structures whilst meeting or exceeding the minimum necessary received signal strength; and

c) Meet safety requirements, including lightning protection, structural strength and radiation exposure.

d) Satisfy specified performance objectives

2.2 Radio Equipment

The design of L-Band VSAT BGAN satellite SCADA radio links shall be based on the following equipment types and parameters.

a) All antennas shall be the Hughes 9502 ODU part number 3500564-0001 (385mm x 385mm x 33mm flat panel);

b) All radios shall be the Hughes 9502 IDU type;

c) All coaxial cabling, surge arrestors and connectors shall be 50 Ω impedance;

d) Feeder cable shall be installed in accordance with Section 3.5 - Feeder Cables; insertion loss between the IDU and the ODU shall be 1.8 ± 0.5dB at 1.6Ghz between the N- male TNC type RF connector on the IDU (radio) and the male N-type RF connector on the ODU (antenna);

e) All installations shall have a global beam received signal strength in accordance with Section 2.6 – BGAN VSAT Signal Level Measurements;

f) All installations shall have lightning surge suppression installed in accordance with Section 4.1 – Lightning Surge Suppressors;

g) All antennas, antenna support structures, cable pathways, building/cabinet entry points, surge arrestors, and coaxial feeder cables shall have Earthing, Bonding and Lightning Protection compliant with the DS 42-03 SCADA Radio Equipment and Installation;

h) All 12 or 24 VDC power feeds to the IDU shall be provisioned from a circuit breaker on a circuit board; and

i) Equipment and cable labels shall be provisioned and installed in accordance with the requirements of Design Standard DS 26-09 and the JT17 Drawings

Note that equipment parameters (i.e. output power) are fixed by the IDU and are not user-configurable.

2.3 Antenna Location

The location of the VSAT antenna within a Water Corporation site shall be determined by either:

a) A desktop map study (e.g. Dish Pointer or similar online tools) in combination with the Hughes satellite pointing tool and/or;

b) A site visit, given prior approval of the nominated Water Corporation representative.

Where a feasible location for the VSAT antenna is not possible (i.e. due to vegetation or particularly steep terrain) the design engineer shall recommend one or more alternatives, however this circumstance should only rarely arise given the relatively steep elevation of the VSAT antenna required within Western Australia. Elevations range from 40° in the Great Southern to 65° in the Kimberley Region.

Section 3.2 describes the preferred mounting location for VSAT antennae at each site.

Section 3.5 describes the coaxial cable loss requirements between the active IDU and the passive ODU.

2.4 Radio Path Analysis Parameters

The Hughes BGAN platform used for the Inmarsat satellite is a closed network solution. No radio path analysis is required for antennas that have a clear sight to the satellite. Clear line of light shall be established during a site visit by a suitably qualified communications engineer and/or a Water Corporation representative. A 5° clearance shall be maintained as a minimum to mitigate obstructions (and therefore signal degradation). Possible obstruction due to future growth of trees shall be identified and avoided.

Where radio path analysis is requested, this should be carried out by a suitably qualified communications engineer.

2.5 Frequency Planning

The Inmarsat BGAN platform uses the L-Band radio frequency spectrum as determined by the satellite operator; therefore no specific frequency planning is necessary.

The Inmarsat BGAN equipment is licensed under the Radiocommunications (Communication with Space Object) Class Licence 1998[1]. To prevent interference to the Murchison Radioastronomy Observatory (MRO) Radio Quiet Zone (RQZ), the following class license restrictions apply:

- "This Class Licence does not authorise operation of a station when and where the operation could interfere with the operation of radio astronomy observations by...the Murchison Radioastronomy Observatory"
- Restriction on operations "at any time in the frequency range 1660 to 1660.5 MHz within 500 kilometres distance from a radio Observatory" i.e. the Murchison Radio Observatory (MRO)[2]; and
- Restriction on interference originating from class licensed devices located within 70 km of the MRO[2].

Compliance with the class license restrictions shall be achieved with one of the following solutions:

- Locate the BGAN equipment at a distance greater than 500 km from the MRO;
- Receive written confirmation from the satellite operator that the BGAN equipment will not transmit in the frequency range of 1600 to 1660.5 MHz;
- Receive written confirmation from the MRO for installation of BGAN equipment between 70 and 500 km distance from the MRO; or
- Do not install BGAN equipment and install alternative equipment at a distance less than 70 km from the MRO.

[1] Radiocommunications (Communication with Space Object) Class Licence 1998
http://www.comlaw.gov.au/Details/F2012C00166/674d7097-022c-43c0-bbc5-9658241757f4
[2] The Murchison Radio Observatory is defined as latitude 26.704167 South, longitude 116.658889 East (GDA94) in Radiocommunications (Communication with Space Object) Class Licence 1998

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2.6 BGAN VSAT Signal Level Measurements

Signal level measurements shall be undertaken on all BGAN VSAT installations.

All BGAN VSAT installations shall have a Narrow Band received signal strength ≥ 62dB. This measurement is the ratio of received carrier power to noise power (C/N).

Refer to Section 5.2 for details on pointing and signal strength measurement procedures.

Signal level measurements in pointer mode and narrow band shall be undertaken and recorded in Appendix A – Commissioning Checklist on all BGAN VSAT installations.

The ODU antenna shall be optimised for the received signal strength using the manufacturer prescribed feature. Note that the IDU will not transmit whilst in pointing mode.

3 External Plant Equipment

External plant equipment includes antennas, antenna support structures, antenna feeder cables, surge suppressors, cable ladders and trays, catenaries or metal conduits connecting an antenna support structure to an equipment area, earths and external bonding cables.

Equipment mounted externally, or in locations subjected to external conditions, shall:

- Meet or exceed the requirements of AS/NZS 1170 parts 1, 2, and 4;
- Withstand wind forces and remain stable under wind force conditions defined in AS/NZS 1170.2 assuming a mean return interval for the design wind velocity of 100 years.;
- Withstand seismic conditions corresponding to an intensity level of 6 on the Mercalli Scale.

All antennas, antenna support structures, cable pathways, building/cabinet entry points, surge arrestors, and coaxial feeder cables shall have Earthing, Bonding and Lightning Protection compliant with the DS 42-03 SCADA Radio Equipment and Installation; and

Refer to section 4 of this standard for full details of earthing and bonding requirements for lightning protection.

3.1 Safe Antenna Radiation Clearances

3.1.1 Antenna Radiation Clearance Zone

Safe antenna radiation clearances shall be provided for and observed by any personnel using adjacent walkways or work areas. The minimum safe radiation distance is 1 metre when in front of or at the

[3] Mid West Radio-Quiet Zone – November 2013 Factsheet http://www.atnf.csiro.au/projects/askap/ASKAP_FAQ_Pastoralists_Nov2013.pdf

side of the antenna. RF radiation hazard signage shall be installed in clearly visible locations in close proximity to the antenna. Figure 3-1 shows sign details. Signs are available by contacting the SCADA help desk on 9273 4622.

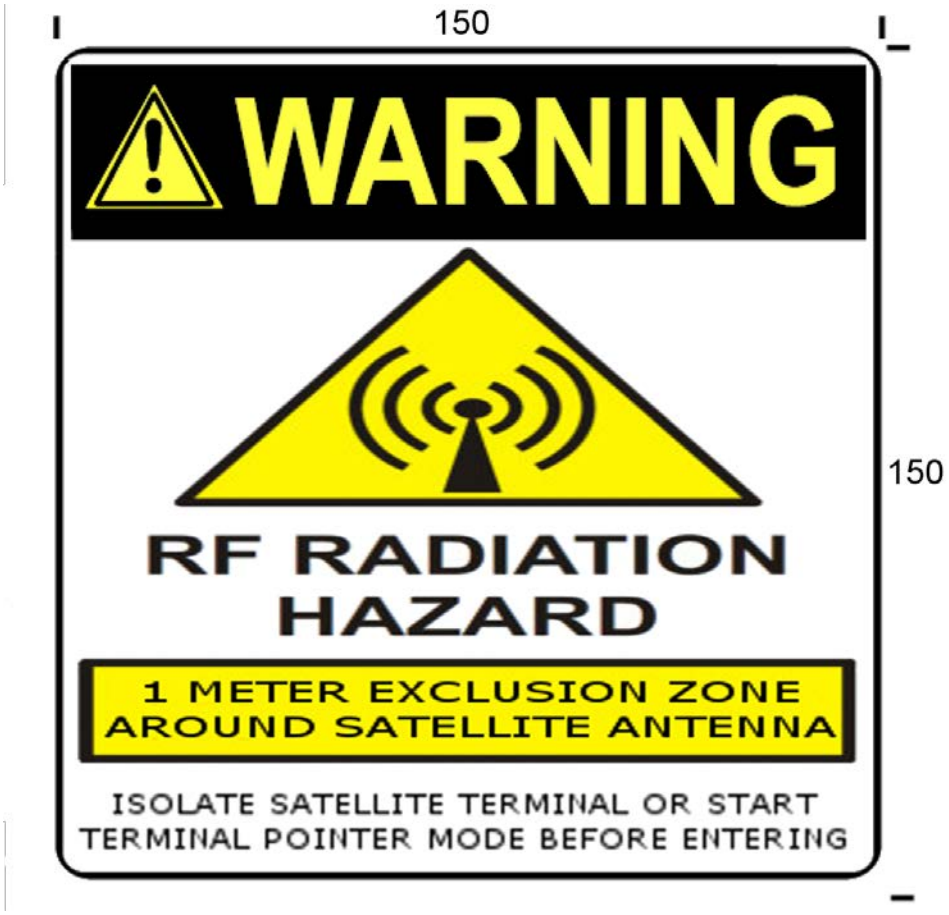

Figure 3-1 Antenna RF Radiation Hazard Sign

3.1.2 Antenna Radiation Pattern

The Hughes 3500564 antenna has 12 dBi gain with at 3 dB beamwidth of 30 degrees at 1,643.5 MHz The antenna gain pattern for the Hughes 9502 External Antenna ODU 3500564-0001 at 1643.5 MHz, RHCP gain, phi=0/90 (rotation about bore sight) is displayed in the following image.

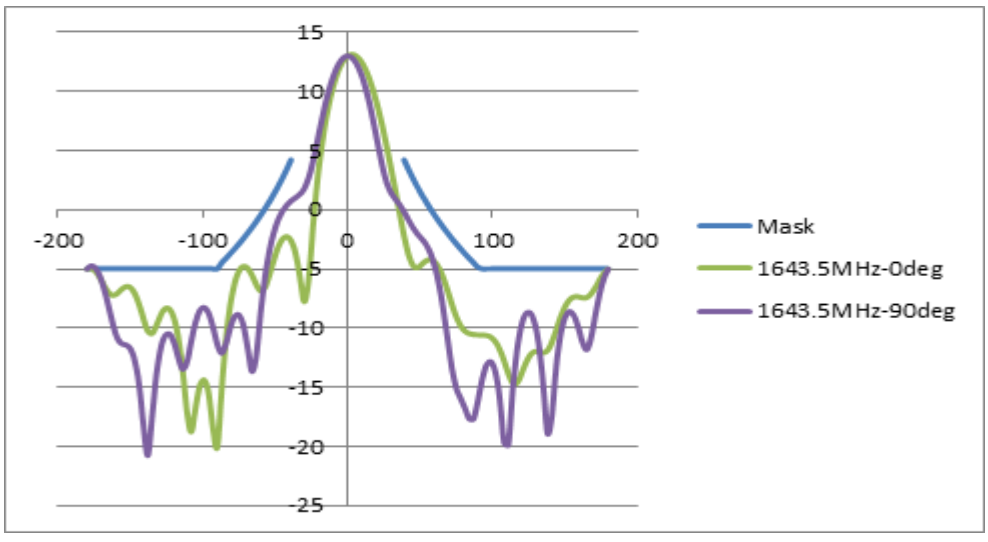

Figure 3-2 Hughes 9502 External Antenna ODU 3500564-0001 Antenna Gain

The polar plot of the antenna is shown in Figures 3-3 and 3-4 below in plan and profile view respectively. Note that the vertical and horizontal propagation models are the same.

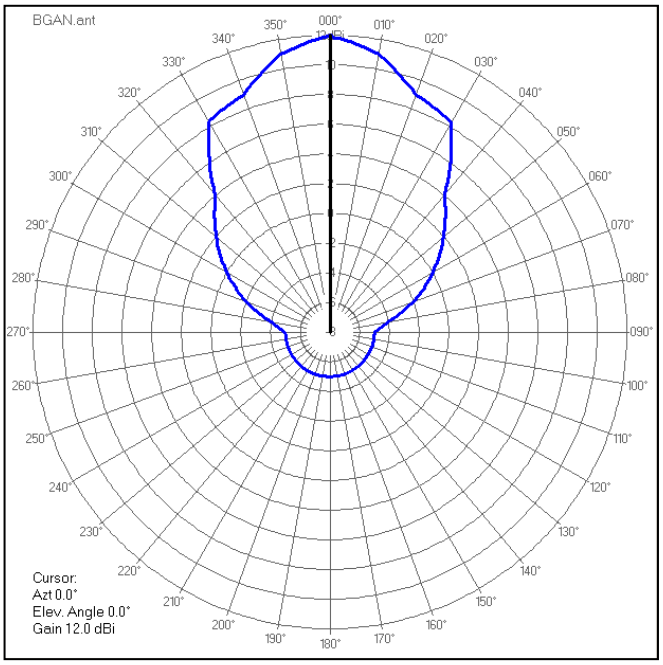

Figure 3-3 Hughes 9502 External Antenna ODU 3500564-0001 Plan Antenna Gain

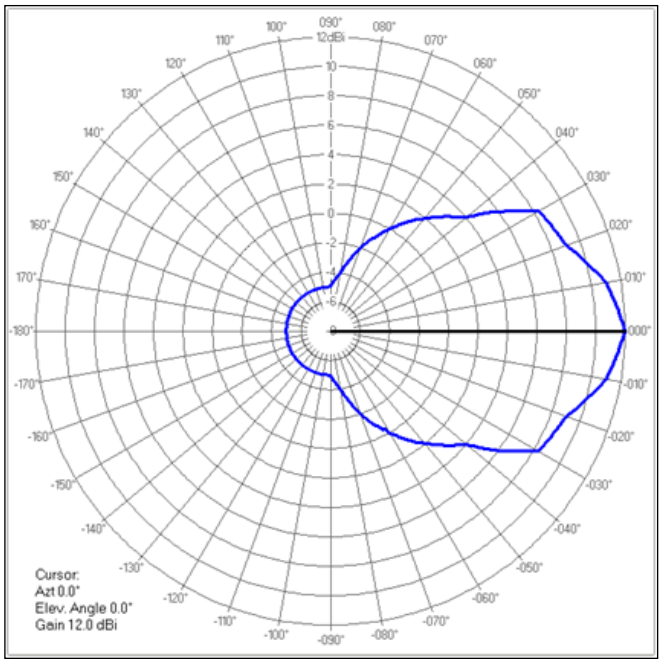

Figure 3-4 Hughes 9502 External Antenna ODU 3500564-0001 Profile Antenna Gain

The radiation hazard zone for the antenna in plan view is shown in the following image. The radiation hazard exists in the area one metre from in front of the antenna, 20 cm behind the antenna, and 35 cm either side of the antenna.

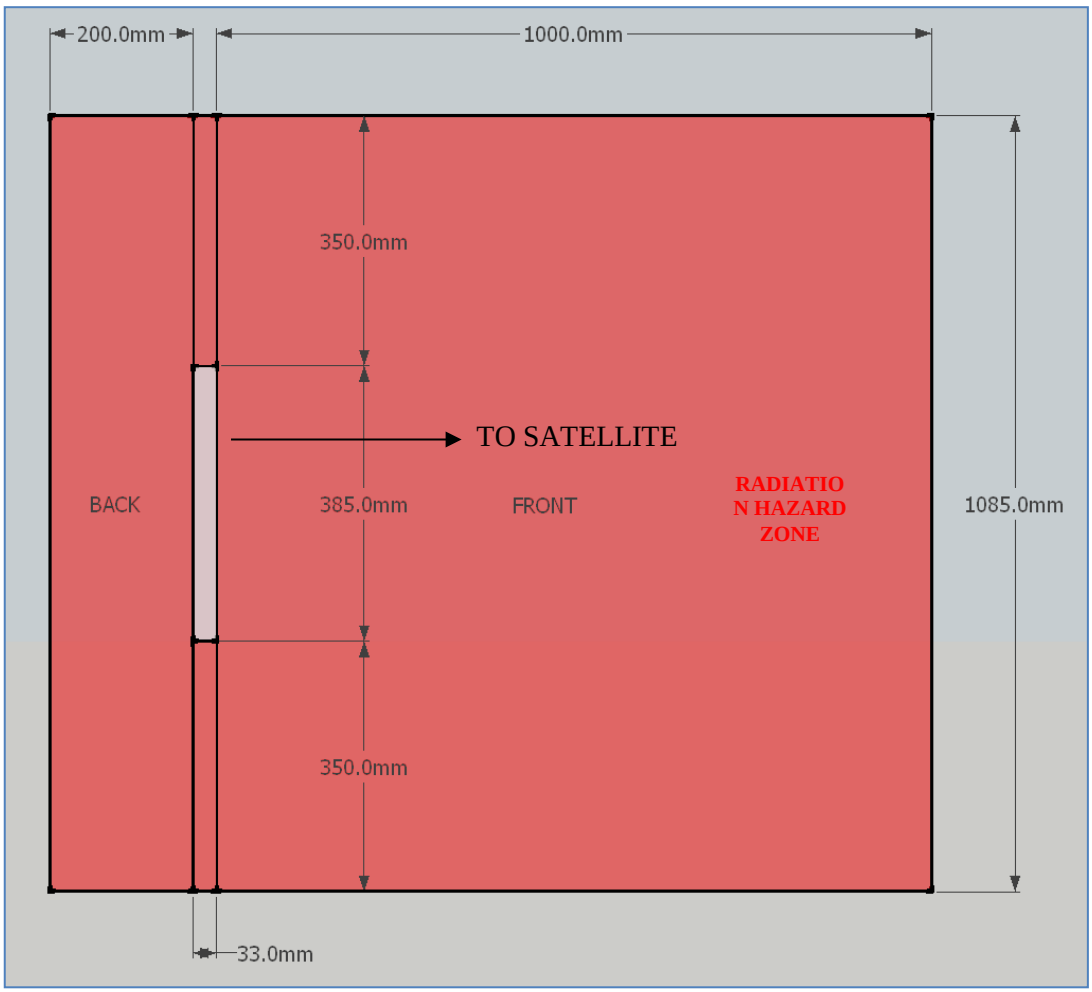

Figure 3-5 Hughes 9502 External Antenna ODU 3500564-0001 Plan View Radiation Hazard Zones

The exclusion zone for the antenna in profile view is shown below. The radiation hazard exists in the area one metre from in front of the antenna, 20 cm behind the antenna, and 35 cm either side of the antenna. Theses distances are referenced to the installed plane of the antenna which is nominally 45º above the horizon.

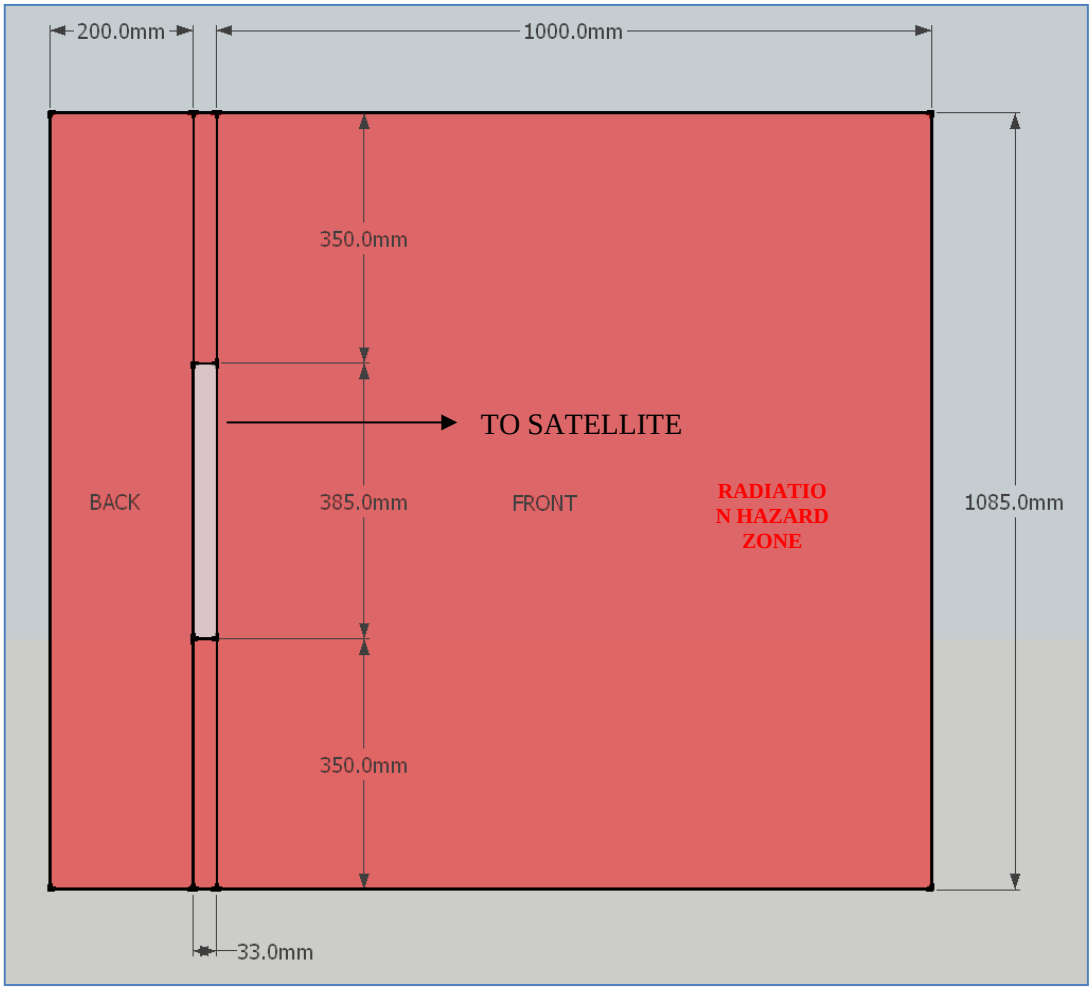

Figure 3-6 Hughes 9502 External Antenna ODU 3500564-0001 Profile View Radiation Hazard Zones

3.2 Antenna Support Structures

3.2.1 Pole Attached to Non-Metallic Building

Where possible the included Hughes pole and base bracket shall be used to affix the antenna to the building. The antenna and bracket shall be bonded to the structure in compliance with the Corporation standard DS 42-03.

3.2.2 Pole Attached to Metallic Building or Cubicle

Where possible the included Hughes pole and base bracket shall be used to affix the antenna to the cubicle. The antenna and bracket shall be bonded to the structure in compliance with the Corporation standard DS 42-03.

3.2.3 Free Standing Poles

Note: The use of free-standing poles requires written approval by the Principal SCADA Engineer prior to installation.

Free standing poles may be rigid or hinged – see Section 3.2.4 for hinged poles. Unless otherwise stated, “free standing poles” shall mean rigid poles in this Standard.

Free standing antenna poles shall consist of steel columns of varying height similar to the INGAL EPS ‘Park’ range of octagonal columns. Any free-standing pole shall be capable of supporting the 1.85kg

ODU plus any additional cable/connector weight and take into consideration the wind loading characteristics of the 385mm x 385mm x 33mm (W x H x D) antenna panel/ODU.

The free standing pole shall be mounted on a galvanised steel screw pile, or reinforced concrete foundation.

The free standing pole shall not be fitted with climbing rungs.

Antenna feeder cables running down a hollow type antenna support shall be run inside the pole, with a top exit pipe and gland fitting that will support the full length of cable inside the pole such that no excessive stress is exerted on the cable and the cable minimum bending radius is not exceeded.

An earth strap connection shall be provided at the bottom of the pole adjacent to the antenna feeder cable entry. Where required the pole shall provide cable entry points for the feeder cable(s). All holes for cable entries shall be equipped with glands or rubber grommets to protect cables passing through the openings.

All feeder cables from free standing steel poles shall be run underground in medium duty white non-metallic conduit, unless specified otherwise. The cable entry at the shelter shall be sealed to prevent water entering the shelter.

The free standing pole shall include the communications earth - see Section 4 – Earthing, Bonding and Lightning Protection.

The antenna and bracket shall be bonded to the structure in compliance with the Corporation standard DS 42-03.

3.2.4 Hinged Poles

Note: The use of hinged poles requires written approval by the Principal SCADA Engineer prior to installation

Rigid free standing poles shall be used in preference to hinged poles unless either of the following two circumstances is evident:

a) The pole is located in a position that has unsound or uneven ground that would make the use of a cherry picker or similar personal lifting equipment dangerous;

b) The location of the mast pole is such that it would not be economical or efficient to arrange the use of a cherry picker or similar personal lifting equipment.

Under the above conditions, the use of hinged antenna support poles shall be permitted provided **all** of the following conditions are met:

a) The Principal SCADA Engineer has provided written approval to install a hinged pole

b) The pole height is ≤ 20m; and

c) The antenna feeder cable is flexible coaxial cable; and

Note: The use of rigid Corrugated Heliax cable not permitted under any circumstances with hinged poles.

d) The antenna feeder cable is installed and internally supported such that no excessive stress is exerted on the cable at any stage, including during pole lowering; and

e) There are no antenna feeder cable in-line connectors, for example at the hinged point; and

f) It is not necessary to disconnect and remove the antenna feeder cable from the base of the pole and/or from an underground conduit at the lower end, in order to lower the pole; and

g) The installer can demonstrate that the above conditions are met to the satisfaction of the Water Corporation.

An earth strap connection shall be provided at the bottom of the pole adjacent to the antenna feeder cable entry. Where required the pole shall provide a cable entry point for the underground feeder cable. All holes for cable entries shall be equipped with glands or rubber grommets to protect cables passing through the openings.

All feeder cables from hinged poles shall be run underground in medium duty white non-metallic conduit, unless specified otherwise. The cable entry at the shelter shall be sealed to prevent water entering the shelter.

The hinged pole shall include the communications earth - see Section 4 – Earthing, Bonding and Lightning Protection.

The antenna and bracket shall be bonded to the structure in compliance with the Corporation standard DS 42-03.

3.2.5 Antenna Attached to Ground Water Tank or Water Tower

Note: The use of antenna affixed to ground water tanks or water towers requires written approval from the Principal SCADA Engineer prior to commencement of works.

Mounting arrangements for a pole attached to a ground water tank, elevated water tower or any associated structural member such as a railing shall be designed and certified as structurally accep*table* by a qualified structural engineer.

The pole shall be bonded in accordance with the Corporation standard 42-03 to the ground water tank or elevated water tower earthing system – see Section 4 – Earthing, Bonding and Lightning Protection.

Antenna feeder cables shall be run down the outside of a ground water tank and the inside of an elevated water tank, with an earth bonding strap connection at the bottom of the vertical run. Cables shall be supported as specified in Section 3.98.

Where there is not an existing cable ladder or tray, a new cable ladder or tray shall be installed. Mounting arrangements for a cable ladder or tray attached to a ground water tank, elevated water tower or any associated structural member such as a railing shall be designed and certified as structurally acceptable by a qualified structural engineer. The design shall include the type and maximum depth of fasteners (as a minimum).

The antenna and bracket shall be bonded to the structure in compliance with the Corporation standard DS 42-03.

3.3 Distance between Pole and Building or Cubicle

Free standing and hinged poles shall be located as close as possible to the building or cubicle containing the radio equipment. Long external feeder cable runs shall be avoided. The standard 10 metre feeder cable supplied by AST shall be used. Approval from the Principal SCADA Engineer is required for any other cable use. The feeder cable shall be in accordance with Section 3.5. The feeder cable shall not be run under a road between a pole and a building/cubicle located on the opposite side.

3.4 Antennas

All BGAN VSAT antennae shall be the Hughes 9502 ODU part number 3500564-flat panel ODU type only. All BGAN antennas shall be mounted to provide a minimum safe radiation clearance as defined in Section 3.1 Safe Antenna Radiation Clearances. The antenna shall be installed in accordance with AS/CA S009, specifically Section 17.6. Adequate protection against corrosion due to dissimilar metals shall be provided.

The antenna must be pointed towards the Inmarsat 4 F1 satellite[4]. Antenna azimuth and elevation varies depending on the remote site's latitude and longitude, and can be calculated using desktop or online software (e.g. Dish Pointer), or read from the Hughes BGAN terminal interface when on site. For ease of reference, indicative azimuth and elevation pointing angles are shown in the table below, for selected indicative sites in Western Australia:

Location	Azimuth	Elevation
Augusta	43.7°	40.0°
Perth	44.7°	42.3°
Esperance	35.4°	44.3°
Newman	48.0°	51.8°
Kununurra	44.1°	64.8°

Table 3-7 Indicative Azimuth and Elevation Pointing Angles (WA)

As the table shows, the antennas can be broadly described as being pointed in a north-easterly direction, at an elevation angle of approximately 45°.

The BGAN satellite pointing tool (software) built into the Hughes modem shall be used to precisely determine the appropriate elevation and azimuth when onsite. The antenna requires a clear line-of-sight and the path shall be clear of any obstructions (buildings, trees, etc.). A 5° clearance shall be maintained as a minimum to mitigate obstructions (and therefore signal degradation). Possible obstruction due to future growth of trees should be identified and avoided.

Where possible, BGAN VSAT antennas shall be mounted using the provided Hughes basic fix mount kit and azimuth elevation bracket. It is recommended that the VSAT antenna be mounted in close proximity to the equipment room where the IDU will be located (< 10 metres) to minimise cable losses and allow the supplied manufacturer's feeder cable to be installed.

The preferred installation location of VSAT antennas (on an enclosed site) is, by order of preference:

a) The side of an equipment room;

b) On a free-standing pole of less than 6 meters in height;

c) All other Water Corporation approved mounting options (including taller free-standing poles and hinged poles).

Whenever possible, the VSAT antenna should be installed below the roof line of any equipment rooms and/or water tanks to minimise the likelihood of lightning strikes.

3.5 Feeder Cables

Note: The 10 metre feeder cable supplied with the satellite modem shall be used wherever possible. Any changes to the supplied cable or any other proposed feeder cables must be approved by the Principal SCADA Engineer. Feeder cables where the insertion loss between the IDU and ODU is other than 1.8 ± 0.5dB at 1.6Ghz will not be accepted

[4] The Inmarsat 4 F1 satellite is located in geostationary orbit, approximately 36,000km above the equator at 143.5° East longitude (i.e., above Papua New Guinea).

VSAT antenna coaxial feeder cabling shall be installed in accordance with AS/CA S009 - Installation requirements for customer cabling (wiring rules) and meet the following requirements:

(a) The feeder cable supplied with the modem by Hughes shall be used unless there is no other alternative.

Note: The supplied Hughes 10 metre feeder cable must not be modified in any way.

(b) The cabling solution, inclusive of all cabling, connectors, and surge arrestors shall have a total insertion loss of 1.8 ± 0.5dB at 1.6Ghz between the N- male TNC type RF connector on the IDU (radio) and the male N-type RF connector on the ODU (antenna). Documented proof of these test results must be provided if the feeder cable provided by Hughes is not used;

(c) External antenna feeder cabling shall be provided between the VSAT antenna and the coaxial lightning surge suppressor. External feeder cabling shall be of type LMR400 or LMR600 with a 50 Ohm impedance; be UV stabilised with a non-contaminating sheath; and with a suitable mechanical strength and bending radius

(d) A short, flexible tail shall be used to make the connection to the IDU (radio) and the surge suppressor. The flexible tail shall be of type LMR195 and kept as short as possible, preferably less than one (1) metre. Where the distance between the IDU and the surge suppressor is greater than one (1) metre LMR400 or LMR600 shall be utilised in addition to LMR195;

(e) Pre-manufactured LMR195, LMR400, and LMR600 cabling assemblies, with manufacturer certified insertion losses at 1.6Ghz, shall be used wherever practicable. Manufacturer certified cable assemblies are strongly preferred for quality control and spares provisioning;

(f) All non-certified cabling assemblies shall be site tested for insertion loss at 1.6Ghz;

(g) For insertion loss calculations, each pair of connectors on a cable are assumed to have a 0.1 dB insertion loss;

(h) Pre-manufactured cabling assembly insertion loss records and/or site insertion loss results between the IDU and the ODU shall be recorded for each BGAN installation. Principal SCADA Engineer approval shall be required for all installations to confirm that the installed insertion loss between the IDU and the ODU is 1.8 ± 0.5dB at 1.6Ghz;

(i) All outdoor coaxial connections shall be shall be weatherproofed using self-amalgamating tape (e.g. Nitto no. 15 tape; not provided) and the ODU end of the cable shall be secured to the mounting pole with cable ties;

(j) The cable entry to the equipment room or cabinet shall be sealed to prevent water ingress. Additionally, all cable entries shall be equipped with a gland or rubber grommet to protect the cable passing through the opening;

(k) The minimum bending radius of all cabling shall be fifteen times the cable diameter unless otherwise specified by the manufacturer. **The supplied 10 metre feeder cable has a minimum bending radius of 100mm**;

(l) Excess coaxial cable may be coiled and shall be loomed either behind the antenna, or in the communications cabinet or building;

(m) Cabling shall be well supported and secured to prevent strain on the connectors; and

(n) Cable routing shall minimise any sharp bends, extremes in temperature and/or compression of the cable.

3.6 Connectors

Connectors used for the VSAT antenna installation shall:

a) Be of a professional quality and shall be designed for use with the chosen cable and to match the equipment to which they connect;

b) Be impedance matched to the cable and the equipment;

c) Be hermetically sealed to prevent the ingress of water;

d) Use male N-Type connectors on both the ODU and Surge Arrestor ends of the feeder cable run (e.g. Times Microwave Systems TC-400-NMH-X, Part No. TMC-3190-2626) or RFI N-Plug Crimp CNT-400, Part No. N-205); and

e) Use male N-Type connector on the Surge Arrestor end and male TNC connector at the IDU end. (e.g. RFI N Plug RG58 Crimp, Part No. N-88, and RFI TNC Plug RG58 Crimp, Part No. TNC-26).

3.7 Conduits

Note: Written approval of the Principal SCADA Engineer is required prior to installation of any underground metal conduit.

All conduits and marker tapes shall meet the following requirements:

a) Medium duty non-metallic conduit shall be used for mechanical protection of antenna feeder cables run underground or in exposed above-ground positions, unless specified otherwise;

b) Where specified for mechanical protection, underground conduit shall be installed as defined in Clause 18.6.2 of AS/CA S009;

EXTRACT FROM AS/CA S009

18.6.2 - Places other than public footways or roadways

Underground customer cabling in a location other than a public footway or roadway shall be installed to a minimum depth of 300 mm, measured from the finished ground/pavement surface to the top of the cable or conduit, unless the soil conditions preclude a depth of 300 mm, e.g. solid rock or shale, in which case the cabling may be installed in accordance with one of the following methods:

(a) Installation of the cable or conduit at any depth under a covering of at least 50 mm of fine aggregate concrete.

(b) Installation of the cable in compliant medium duty metallic conduit chased into, or secured to the surface of, the ground and installed in such a way so as not to be hazardous to pedestrians.

(c) Installation of the cable in compliant conduit installed above the surface of the ground and secured against a fixed vertical structure such as a retaining wall or fence.

Note: Installation of metallic conduit and/or steel wire armoured cables in an EPR hazard zone may extend the hazard zone. In such cases, the installation should only proceed on the basis of an engineered design prepared in compliance with the relevant code agreed between the carrier and the power utility. Refer to Clause 6.1 of AS/CA S009.

c) All conduits shall be a minimum 50 mm diameter and all bends shall be sweep bends to facilitate cable installation and possible replacement;

d) All non-metallic conduits shall be white colour;

e) Conduit separation and burial depth, and use of marker tapes shall meet the requirements of AS/NZS 3000;

Note: Orange marker tape shall not be used for communications cable.

f) After installation the inside of the conduits shall be cleaned so they are free of water, dirt and debris.

3.8 Cable Separation Requirements

All communications cabling shall be separated from LV power cables conduits and marker tapes shall meet the following separation requirements:

Extract from AS/CAS009

16.3 Separation from LV power cables

16.3.1.1 General

A customer cable that contains electrically conductive elements, other than an undercarpet cable, shall be permanently separated from any LV power cable by one of the following methods:

(a) A minimum distance of 50 mm.

(b) Subject to the requirements of Clause 16.3.2, a barrier of durable insulating material or metal.

(c) A timber or metal stud, nogging, joist, bearer or rafter of any thickness.

Note 1: Compliance with Item (b) may be achieved by the enclosure of either the customer cable or the LV cable in conduit. Neither the metallic shield of a shielded cable nor the sheath of a double-insulated cable qualifies as a barrier for the purpose of Item (b).

Note 2: It is not a requirement of this Standard for a metallic barrier to be earthed in this case unless it is also used to separate customer cable terminations and LV power terminations (refer to Clause 9.1.2.3). However, in certain circumstances the barrier may be required to be earthed by the installer of the LV power cable as a requirement of AS/NZS 3000.

Note 3: A flexible customer equipment cord is not required to be separated from an electrical appliance cord or fixed LV power cable unless the customer equipment cord is installed as fixed or concealed cabling.

Note 4: Spatial or mechanical separation is necessary for safety purposes to minimise the risk of coincident insulation damage to both the customer cable and the LV power cable caused by excessive heat, abrasion, rodents or penetration by nails or screws.

Extract from AS/CAS009

16.4 Separation from HV circuits

16.4.1 Single-core cables

A customer cable that contains electrically conductive elements and which runs alongside or crosses a single-core cable carrying an HV circuit shall be separated for its entire length from the single-core cable by a distance of at least 450 mm whether or not there is an interposing barrier.

16.4.2 Multi-core cables

A customer cable that contains electrically conductive elements and which runs alongside or crosses a multi-core cable carrying an HV circuit shall be separated for its entire length from the multi-core cable by—

(a) a distance of not less than 300 mm; or

(b) a distance of not less than 150 mm where there is an interposing barrier that—

a. is of such dimensions that at every point the shortest path between the customer cable and the multi-core HV cable around the barrier is at least 175 mm measured from the outside of the cable sheaths; and

b. is made of either durable insulating material or metal earthed in accordance with Clause 20.17.

Note 1: Compliance with Item (b) may be achieved by the enclosure of either the customer cable or the HV cable in conduit.

3.9 Cable Support Requirements

The following cable support requirements shall be observed:

a) Long vertical coaxial cable runs exceeding 3 metres shall be secured using coaxial cable hanger kits at intervals not exceeding 2 metres or as per the coaxial cable manufacturer recommendation;

Note: This requirement does not apply to cables run inside of rigid free standing poles. Cables run inside rigid poles shall be secured at the upper and lower cable entry points. Cables run inside hinged poles shall be secured as specified in Section 3.2.4.

b) Short vertical coaxial cable runs not exceeding 3 metres, e.g. up the outside of a pole, shall be secured using stainless steel clamps at intervals not exceeding 0.5 metre;

c) Where an antenna cable tail joins the main feeder cable at the top of a pole, the vertical cable run shall be secured to the pole using stainless steel cable ties.

d) Above ground antenna feeder cable runs shall be run on steel trays or in steel conduits, at a height of more than 2.5m above ground level to the building cable entry point;

e) Horizontal and vertical runs of coaxial cable that are required to be attached to a surface (e.g. walls, columns, etc.) shall be supported or installed on a cable tray or steel conduit secured at intervals not exceeding 600 mm;

3.10 Labels

Radio equipment labels shall be provided in accordance with the requirements of Design Standard DS 26-09 and the JT17 Drawings.

4 Earthing, Bonding and Lightning Protection

BGAN equipment installation shall be compliant with the Corporation design standard DS 42-03 SCADA Radio Equipment and Installation.

Refer to Section Appendix B - Earthing, Bonding and Lightning Protection

4.1 Lightning Surge Suppressors

A coaxial in line surge suppressor with an earth terminal shall be fitted to protect all SCADA equipment from lightning surges generated by direct and indirect lightning strikes.

The gas discharge surge suppressor shall have Female N-Type connectors be rated for 90V gas discharge (or better), at least 0 – 3000 MHz frequency and pass 24VDC 50W. (e.g. the arrestor recommended by the satellite supplier is Time Protect TC-LP-GTRNFF supplied by Rojone.

The antenna feeder surge suppressor shall be mounted in one of the following locations:

(a) Metal feeder entry gland plate;

(b) Affixed to the metalwork of an internal cable tray;

(c) Where an equipment cubicle or cabinet is free standing, at the point of entry into the cubicle or cabinet or within the cubicle or cabinet as near to the entry point as possible;

(d) Where an equipment cubicle is mounted on an antenna support pole, inside the base of the pole affixed to the earth bar bracket;

The antenna feeder surge suppressor earth terminal shall be bonded to the station earth as per the requirements of the Corporation design standard DS 42-03 SCADA Radio Equipment and Installation.

5 VSAT Communications Commissioning

The VSAT satellite antenna requires accurate positioning in order to achieve reliable radio communications with the BGAN network.

Incorrect positioning can lead to decreased reliability, throughput and availability (i.e. during heavy rainfall) of SCADA communications at the site.

The ODU (VSAT antenna) shall be installed prior to any radio frequency commissioning taking place.

Each installation will require the submission of a completed commissioning checklist for Principal SCADA Engineer approval prior to site acceptance. Refer to Sections 6 Appendix A – Commissioning Checklist.

5.1 Indoor Unit

The IDU shall be located within the SCADA cubicle of the nominated equipment room. The IDU accepts a 12 – 24V DC connection and shall be provided with a dedicated fuse or circuit breaker for circuit protection and to provide a method of turning the IDU on and off.

The GPS and/or NET LEDs will flash when the IDU is attempting to achieve a GPS fix or satellite acquisition respectively. When the PWR, GPS and NET LEDs are solid green, the link is in the operational state and is ready to transmit data.

The IDU connection to the satellite has 3 states. Pointer mode where the IDU is receiving only, Regional Band where the IDU is able to receive and send SMS only and Narrow Band when a full IP connection is established

Note: After a period of time the IDU will turn off all the lights. The unit is still operating correctly and in order to wake up the display you must push the black function button on the front of the unit.

5.2 Antenna Positioning and Signal Strength Measurement

The VSAT antenna shall be installed as per Section 3.2 of this document. The antenna is initially positioned with azimuth and elevation based on latitude and longitude values entered into the Hughes spreadsheet available at http://www.hughes.com/technologies/mobile-satellite-terminals/9502-bgan-m2m-external-antenna-terminal.

The IDU will power up immediately once power is connected. To enter pointer mode push the function button on the face of the unit for 1 second at the point during the power-on-self-test (POST) sequence that the PWR LED is flashing. The PWR, GPS and NET LEDs on the front panel of the IDU will all flash when the IDU is in pointer mode. Note that the IDU will not transmit whilst in pointer mode.

Connect to the IDU web interface as per Section 5.3 in order to read connection status and signal strength values. Accurate pointing of the antenna is achieved by inserting headphones or speakers into the 3.5mm stereo jack of the IDU whilst in pointer mode. The signal strength during pointer mode will be from 46 to 52dB. Change the antenna direction in small increments to achieve the highest pitch beep and therefor highest signal strength possible. Secure the antenna and record the pointer mode signal strength in Appendix A – Commissioning Checklist.

Push the function button to switch out of pointer mode. The IDU will connect to the satellite network and the web interface will indicate Regional Band and then Narrow Band connections. Wait for the Narrow Band connection to be established and stabilised then record the signal strength in Appendix A – Commissioning Checklist. All BGAN VSAT M2M installations shall have a Narrow Band received signal strength ≥ 62dB.

Note that when there is no traffic over the satellite connection for 2 minutes the IDU will drop back to regional band and the signal strength reduced. The narrow band connection can be re-established by pinging the Water Corporation Telemetry WAN firewall at IP address 10.224.1.3 from your PC when connected to the IDU.

5.3 Web Interface

The Hughes 9502 IDU provides a basic web interface that allows for positioning, signal strength confirmation, GPS positioning and log file downloads.

Connect to the IDU with an Ethernet cable and set your PC with;
IP address 192.168.128.101
Subnet Mask 255.255.255.0
Default Gateway 192.168.128.100

Alternatively a USB Type B male to USB Type A male cable can be used however a USB driver is required. Driver available from http://www.hughes.com/technologies/mobile-satellite-terminals/9502-bgan-m2m-external-antenna-terminal.

Entering http://192.168.128.100 in a web browser will bring up the web interface.

The current connection status is indicated on the left-hand-side of the Home page. The web interface will display the current GPS co-ordinates (provided a fix has been achieved) and the current signal strength. Refer to Section 5.2 for suitable signal strength values.

5.4 Connection to Terminal Equipment (TE)

The RJ-45 Ethernet port on the IDU shall be used to connect to the SCADA RTU or Router. Terminal equipment shall have its own private IP address configured as per existing site requirements and/or Water Corporation guidelines.

The IDU will require restarting once the RTU or Router is connected in order to authenticate the IP address. This authentication can be checked by connecting to the web interface selecting the Connections menu and selecting Managed Contexts, The IP assigned to the RTU or Router is the Global IP and should be similar to 10.225.16.XXX

Note that the DB9 serial port on the IDU is not to be used for connection to any terminal equipment. The serial port is only used for connection to a GLONASS receiver or similar device.

6 Appendix A – Commissioning Checklist

Each BGAN VSAT installation shall have the following checklist completed and submitted to the Principal SCADA Engineer for approval prior to site acceptance.

Parameter	Detail	Comment	Installer Initial and Date
INSTALLER DETAILS			
Company Name			
Installer Name (PRINT FULL NAME)			
Installer Signature (PLEASE SIGN)			
Installation Date			
SITE DETAILS			
Site Name			
Site Latitude			
Site Longitude			
Site Contact Name			
Site Contact Number			
Calculated antenna azimuth	_____ **º**		
Calculated antenna elevation	_____ **º**		
BUILDING/CABINET DETAILS			
Building/Room Number			
Cabinet Number			
Rack/Cabinet Position			
Voltage 12/24 VDC			
Measured Line Voltage	_____ **VDC**		
Circuit Breaker Number			

ANTENNA (ODU) DETAILS			
Antenna Location	**Building / Fixed Pole / Hinged Pole / Other** _____		
Installed antenna azimuth	_____ **º**		
Installed antenna elevation	_____ **º**		
Installed antenna height above ground level	_____ **metres**		
Antenna Part Number			
Antenna Serial Number			
FEEDER CABLE DETAILS			
Cables manufacturer certified or custom built	**Manufacturer certified / Custom built**		
Total Insertion loss from IDU to ODU	_____ **dB** **1.8dB ±0.5dB @1.6Ghz required**		
Outdoor cable assembly length	_____ **metres**		
Outdoor cable assembly cable type	**LMR400 / LMR 600**		
Outdoor cable assembly part number			
Lightning surge arrestor Part Number			
Lightning Surge Arrestor Serial Number			
Indoor cable assembly length	_____ **metres**		
Indoor cable assembly part number			
Indoor cable assembly cable type	**LMR195 / LMR400**		
Indoor cable assembly serial number			
CONTROLLER (IDU) DETAILS			
Rack/Cabinet Position			
Voltage 12/24 VDC			
Measured Line Voltage	_____ **VDC**		
Circuit Breaker Number			
Firmware Version			

IDU Part Number			
IDU Serial Number			
SATELLITE SIGNAL DETAILS			
Measured Receive Level	_____ **dB**		
Measured Receive Level	_____ **dB** **≥ 62 dB required**		
RECORDS			
Photo facing the front plane of the antenna from a distance of ten (10) metres.			
Photo facing the satellite from under the antenna.			
Photo facing the left hand plane of the antenna from a distance of ten (10) metres.			
Photo facing the right hand plane of the antenna from a distance of ten (10) metres.			
Photo of the cabling at the rear of the ODU			
Photo of the cabling at the building/cabinet entry point			
Photo of the surge arrestor affixed to the building/cabinet entry point			
Photo of the cabling at the rear of the IDU			
Photo of the cabling at the front of the IDU			
Photo of the cabling to the power feed for the IDU			
Photo of the rack position of the IDU			
LIGHTNING, EARHTING, AND BONDING			
Confirm that lightning, earthing, and bonding are compliant with the requirements of DS 42-03	**Compliant / Non-compliant**		
VSAT BGAN INSTALLATION			
Confirm that the BGAN VSAT installation is compliant with the requirements of DS 42-01	**Compliant / Non-compliant**		
Action Items			

Parameter	Detail	Comment	Engineer Initial and Date
PRINCIPLE SCADA ENGINEER APPROVAL			
Position			
Name (PRINT FULL NAME)			
Signature (PLEASE SIGN)			
Site Acceptance	**Complete / Re-work Required**		
Site Acceptance Date			
Action Items			

7 Appendix B - Earthing, Bonding and Lightning Protection

Where a satellite antenna is to be installed on a large antenna support structure the earthing, bonding and lightning protection shall be in accordance with DS 42-03 SCADA Radio Equipment and Installation. For an installation where the satellite receiver is attached via a mounting bracket to a building or cubical the earthing, bonding and lightning protection shall be in accordance with AS/CA S009 – Installation requirements for customer cabling (wiring rules), specifically clause 17.6 Outdoor Antennas.

EXTRACT FROM AS/CA S009

17.6 Outdoor antennas

Where an outdoor radio, wireless ('Wi-Fi') or satellite antenna (including any active/powered antenna referred to as an 'Outdoor Unit' or 'ODU') is connected to customer cabling, the following should be met:

a) To minimise static electricity charge and for lightning protection purposes, the antenna metal support, mast and boom (as applicable) should be earthed in accordance with Clause 20.19.

Note: The lightning protection is limited to shunting induced current from a nearby lightning discharge to earth and will not provide effective protection against a direct lightning strike.

b) In areas of high lightning activity, if the highest extremity of any part of the antenna, including the cabling connected to it, is less than 2 m below the apex of the roof or more than 1.5 m from the building, the following should be met:

   i. Earthing conductor installed in accordance with Item (a) should have a cross-sectional area of at least 6 mm² and should be run by the most direct route to a suitable equipotential bonding point in accordance with AS/NZS 1768.
   ii. If the cable feed from the antenna is coaxial cable, the coaxial cable should be connected to the indoor equipment via an isolator that provides a minimum isolation of 3 kV r.m.s. and 7 kV impulse, and the outer conductor of the coaxial cable should be earthed on the antenna side of the isolator to the same equipotential bonding point described in Item (b)(i) via an earthing conductor with a cross-sectional area of at least 2.5 mm².

c) To reduce the severity of any atmospheric (lightning) discharge coming down the cable feed from the antenna to the equipment, an inductive loop (typically 3 turns of cable approximately 200 mm in diameter) should be formed in the outdoor portion of the cable feed (e.g. near the antenna connection).

Earthing and bonding shall be provided in accordance with DS 21, DS 22 or DS 28 with the additional requirement that, at sites where one or more external radio antennas are installed, a separate communications earth and bonding system shall be provided for lightning protection.

Lightning protection shall be provided in accordance with AS/NZS 1768, AS/CA S009 and DS 40-09, except where varied in Clause 4 of this Standard.

7.1 Background

The lightning protection specified in this Standard is based on the risk assessment procedures and spreadsheet tool, and structural earthing information contained in AS/NZS 1768. These are covered in more detail in the following two sections.

7.1.1 Risk Assessment

The risk assessment compares calculated risks with levels of risk that are acceptable to the Water Corporation. Where the calculated risk exceeds the acceptable risk, lightning protection measures shall

be implemented. Conversely, where the calculated risk is less than the acceptable risk, additional lightning protection measures are not required.

The risk assessment at typical Water Corporation SCADA radio sites shows that many, but not all, lightning protection measures contained in AS/NZS 1768 should be provided. Appendix A contains two typical risk assessments using the spreadsheet from AS/NZS 1768. The first is for a SCADA radio repeater and the second for a SCADA local site. Similar results are obtained for all areas of the State, where the number of annual thunder days varies from 10 to 80.

The risk assessment spreadsheets show the following:

a) The risk of loss of human life due to a direct or indirect lightning strike is negligible and well below the level of acceptable risk;

b) The risk of loss of essential services and economic loss due to a direct lightning strike is likewise negligible and well below the level of acceptable risk;

c) The risk of loss of essential services, and in some cases the economic loss, due to an indirect lightning strike is significant and higher than the level of acceptable risk.

Based on this risk assessment:

a) AS/NZS 1768 mandates that protection measures shall be taken to minimise the risk of loss of essential services and economic loss due to an indirect lightning strike. The lightning protection measures include comprehensive equipotential bonding and use of surge protection devices on all SCADA equipment.

b) AS/NZS 1768 does not require that additional measures should be undertaken to protect the site from a direct lightning strike. In particular:

- It is not required that a lightning protection earth resistance of ≤ 10 ohms should be provided;
- It is assumed that metal support structures such as poles, masts and towers are electrically bonded throughout and will provide low surge impedance to lightning strikes, ie there is no requirement for additional bonding between structural members;
- It is assumed that support structure foundations and metal bases will provide relatively good earth terminating points for lightning protection. This item is covered further in the following section.

7.1.2 Earthing of Antenna Support Structures

Antenna support structures such as free standing poles, towers or guyed masts are inherently good lightning downconductors and their foundations/bases provide relatively good earth terminating points for lightning protection. As a result, there is no requirement for the installation of separate lightning protection downconductors or earth terminations such as earth rods or trenched conductors.

Each free standing pole, tower or guyed mast will utilise a reinforced concrete foundation or in the case of some poles, a metallic screw pile base. The latter is used for poles of ≤ 20m height where structural loading permits and soil conditions allow the base to be mechanically screwed into the ground using a hydraulic rig. A concrete foundation is required for higher structures, and where the structural loading is too high and/or the soil is too hard for a screw pile base. Concrete foundations require mechanical excavation of the soil to 1m depth or more.

A reinforced concrete foundation or metal screw pile base will provide an adequate earth termination for a lightning protection system. The metal screw pile base has a large area that is in direct contact with the earth. Section 4.5.2.4 of AS/NZS 1768 states that concrete foundations are deep in the mass of earth and the resistivity of concrete is generally comparable with that of clay or other moderately conductive ground and that concrete foundations themselves will constitute a satisfactory earth termination point.

The structure mounting bolts that are cast in situ into the concrete base will provide lightning discharge paths from the structure to the steel reinforcing rods. The mounting bolts and reinforcing rods, welded or tied together by steel tie wire at splice points, will provide a multiplicity of parallel discharge paths to earth via the concrete.

7.1.3 General Arrangements for Communications Lightning Protection

The JT17 Drawings include general mandatory communications earthing and bonding arrangements to assist with the implementation of the following requirements.

7.2 Earthing Requirements

The Corporation has a variety of enclosures and structures that are used to house the communications equipment and provide appropriate antenna support structures respectively. The most common installations are addressed below.

The communications earth types are as follows:

a) Type 1: antenna support structure provides the communications earth;

b) Type 2: a separate communications earth is required;

c) Type 3: the communications earth is combined with the station earth.

7.2.1 Type 1 Communications Earth

For a free standing pole, tower or guyed mast the communications earth termination point shall comprise, as a minimum, a reinforced concrete foundation or metal screw pile base.

Note: It will not be necessary to install earth rods or trenched conductors for the communications earth.

A communications earth connection point shall be provided at the base of the free standing pole, tower or guyed mast for bonding to the station earth and other metallic points - see Section 4.4. This connection point shall be known as the “communications earth”.

Note: The communications earth connection point may be incorporated into the structure, for example using a welded spigot or an earth bar inside of a pole, provided the connection is adequately protected from corrosion and damage.

7.2.2 Type 2 Communications Earth

For a pole attached to a non-metallic building such as a brick building, a separate communications earth shall be provided. This communications earth shall be bonded to the station earth.
The communications earth shall comprise one of the following:

a) A single 1.2m copper coated steel earth rod driven into the ground as close as practicable to the pole, with a copper bracket welded to the rod for attaching bonding cables;

Note: The copper bracket may be welded to the earth rod prior to installation.

b) Where it will be unsafe or impractical to drive or otherwise install a 1.2m earth rod due to existing underground plant or rock, a trenched communications earth shall be installed comprising a minimum 5m length 70 mm2 bare hard drawn copper cable buried to not less than 0.5m.

Where an alternative communications earthing and bonding system is proposed, details shall be submitted to the Water Corporation for approval.

7.2.3 Type 3 Communications Earth

In the following situations the communications earth shall be the station earth:

a) For a pole attached to the metal frame of a metallic building or cubicle;

b) For a pole attached to a ground water tank, elevated water tower or any associated structural member such as a railing;

c) For a low profile antenna;

d) For an internal cubicle within a building or elevated water tower.

In all situations the combined earthing and bonding system shall meet all of the lightning protection requirements contained in this Standard.

7.2.4 Earth Bonding Points

For a Type 1 communications earth, there shall be provision for a separate isolated connection for the bonding cable at both the communications and station earths.

For a Type 2 communications earth, a communications earth pit shall be provided for connecting bonding cables to the communications earth. As a minimum, there shall be provision for separate isolated connections at the communications earth for bonding cables to:

a) The antenna support structure; and

b) The station earth.

7.2.5 SCADA and Radio Equipment Earth Connection

The negative terminal of the SCADA and radio equipment power supply and battery bank shall be connected to the radio cubicle/cabinet earth bar. The point of connection at the earth bar shall be a suitable isolation point for fault finding and maintenance.

All equipment negative or earth points shall be connected via a suitable distribution bus and cables to the negative terminal of the battery and/or power supply.

7.2.6 Station Earth

Prior to bonding to a Type 1, 2 or 3 communications earth, the station earth shall be inspected and tested to confirm that is complies with the relevant electrical standards, including the measurement of the station earth resistance where relevant.

Note: There is no need to retest the station earth where there is documentary evidence that the earth has been tested within the past two years and meets the relevant electrical standards.

Where the station earth is found to be noncompliant, the matter shall be referred to the relevant regional office for corrective action.

7.3 Bonding

All equipment shall be suitably bonded to ensure that lightning strikes are given a direct path into the mass of the earth and to minimise the effects of electrical surges, potential differences and flashovers during a lightning strike, in accordance with the following requirements.

7.3.1 Structural Bonding

a) In a concrete foundation, the structure mounting bolts shall be electrically bonded to the steel reinforcing bars and all reinforcing bars shall be electrically bonded together at all splice points;

b) The structure shall be secured to the foundation mounting bolts so as to provide good electrical connectivity;

c) All guy anchor points of a guyed mast shall be bonded by a minimum 35 mm^2 bare hard drawn copper cable to the communications earth. The bonding cable shall be directly connected to each metallic guy to provide good electrical bonding, bypassing ohmic junctions on joints, turnbuckles or pins;

d) A minimum 35 mm^2 bare hard drawn copper cable buried earth ring shall be provided to bond all legs of a free standing tower together and to the communications earth;

Note: Buried earth rings are not required for free standing poles with either galvanised steel screw piles or reinforced concrete foundations.

e) For a pole attached to any building, metallic cubicle, water tank or elevated water tower the antenna support structure shall be directly connected by a minimum 6 mm^2 insulated copper cable to the station earth;

Note: Bonding is not required where the antenna support pole is secured to, and makes good electrical connection to a metallic structural member that is connected to the station earth.

f) External cable trays, catenaries or metal conduits connecting an antenna support structure to an equipment area shall be bonded by a minimum 16 mm^2 insulated copper cable to the structure and the communications earth;

Note: Bonding is not required where the external cable trays, catenaries or metal conduits are secured to, and make good electrical connection to the structure.

g) The metalwork of internal cubicles, cable trays, equipment racks and cabinets shall be bonded together and to the station earth by a minimum 6 mm^2 insulated copper cable.

Note: For Item (g) bonding conductors shall be directly connected to the station earth or to another point on the earthing system that is connected to the station earth.

7.3.2 Earth Bonding

a) Type 1 and 2 communications earths shall be directly bonded to the station earth by a minimum 35 mm^2 bare hard drawn copper cable;

b) The cable shall be run to the station earth by the shortest practical route and shall not be bonded to another point that is connected to the station earth;

c) Where the cable is exposed to mechanical damage and it is not possible to use conduit for protection, for example over a concrete slab, bare hard drawn copper cable may be used;

d) Where the cable enters a building and/or a switchboard it shall be insulated.

Note: Bare copper earth bonding cable shall not be run inside a building or switchboard.

7.3.3 Surge Suppression Bonding

a) Antenna feeder surge suppressors shall be bonded by a minimum 6 mm^2 insulated copper cable to the station earth;

Note: The bonding cable shall be directly connected to the station earth or to another point on the earthing system that is connected to the station earth.

b) Metal feeder entry gland plates shall be bonded by a minimum 16 mm^2 insulated copper cable to the station earth.

Note: The bonding cable shall be directly connected to the station earth or to another point on the earthing system that is connected to the station earth.

7.3.4 Antenna and Feeder Cable Bonding

a) Antennas shall be mounted to provide good electrical bonding to the support structure;

Note: This requirement is not applicable to some low profile antennas.

b) Each external antenna feeder cable shall be bonded to the support structure in at least one place, namely just before the bend to the horizontal at the bottom of the structure. The earth bonding connections shall be wrapped in self-amalgamating tape and further wrapped with electrical tape to ensure that the connection is protected against the ingress of moisture and chemicals.

Note: For a pole attached to a non-metallic building, metallic building or cubicle it is not necessary to provide a feeder cable earth strap connection at the bottom adjacent to the cable entry.

7.3.5 Bonding General

Boding shall be to the requirements of the design standard DS 42-03 SCADA Radio Equipment and Installation. As a guide, the requirements are:

a) All bonding cables shall follow the shortest and most direct path to earth and shall not be coiled;

b) The maximum volt drop across all bonding connections at 25 Amp shall be less than 0.1 volt;

c) Earth cables shall be kept as far away as possible from steel trays or structures to ensure that the lightning current surge impedance is a low as possible;

d) All external earth connections shall be protected from the weather by suitable applied coatings of anti-oxidant and protective coating such as self-amalgamating tape, Denso grease and Denso tape;

e) All connections and bonding shall be protected from galvanic corrosion due to chemical reaction between dissimilar metals;

f) Lugs shall be used for all bonding cable connections.

7.3.6 Underground Bonding Cable

a) All bonding cables connecting to the communications earth at the base of the antenna support structure shall be run through a concrete foundation in at least 50 mm diameter medium duty non-metallic white conduit and all bends shall be sweep bends;

b) Elsewhere, earthing and bonding cables shall be directly buried in the ground unless specified otherwise. The separation of buried cable from other underground services, burial depth, and use of marker tapes shall meet the requirements of AS/NZS 3000;

Note: Orange marker tape shall not be used for earthing or bonding cables.

c) Where specified for mechanical protection, medium duty non-metallic white conduit shall be used for earthing and bonding cables.

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