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1. Introduction

Christmas Island is an external Australian Territory which is located in the Indian Ocean, approximately 2,600km northwest of Perth, Western Australia, and approximately 300km south of the Indonesian capital Jakarta. The island covers an area of approximately 135 square kilometres and is 19km across at its widest point.

The purpose of the project is to improve the communications infrastructure on Christmas Island for emergency response and recovery, business and the wider community. The radio network is primarily for the use by the IOTA field officers and management in the co-ordination of search and rescue activities and interfacing with other agencies and volunteers and vessels at sea.

The current Christmas Island communications infrastructure provides a 2G Telstra mobile phone service and a number of VHF / UHF two-way radio networks. The mobile phone service is predominately limited to the settled areas on the northern part of the island and the two-way radio network is limited by the dense vegetation, topography and location of existing infrastructure. Shadowing of the radio signal from the existing repeaters also occurs on the ocean close to the island because of the steep terrain, stepped terraces and sheer cliffs which surround the majority of the island.

The project objective is to design an island wide communications system that utilises and builds upon existing infrastructure. An appropriate design solution will improve the existing network coverage on Christmas Island and surrounding ocean and allow easier communications between IOTA, other agencies, community groups and commercial organisations.
2. Requirements Specification

The requirements as stated in the project brief include

1. The design is to allow for improvements to the existing system during the first year, within the constraints of the existing budget and to allow for network improvements and enhancements in future years

2. An island wide communication system with, given the topography, vegetation and environment a minimum of potential black spots

3. Multi-agency access

4. Maximum coverage

5. Provide a robust system suitable for the Island environment: e.g. tropical, high rainfall and proximity to breaking surf

6. Design a robust system which will remain live during emergency events

7. The successful may be engaged to provide advice during procurement and implementation of the design along with ensuring the works meet design standards

During consultation with IOTA on Christmas Island during May 2015, the following additional requirements were defined.

1. A basic network monitoring system to allow reporting of remote site alarms to the IOTA office.

2. Provision of a portable repeater system for use in areas where the coverage from fixed repeaters is inadequate.

3. The provisioning of a phone patch system to allow calls to and from the public telephone network.
3. **Scope**

This document includes a high level specification of the internal structure and functionality of the radio system and associated supporting infrastructure. The sections of this document address the following.

1. Radio network predicted coverage
2. Radio Repeaters configuration
3. Radio linking configuration
4. Audio bridging and inter-agency network Interfacing
5. Site build specification (tower, cabinet, environmental lightning/earthing)
6. Power systems for communications facilities
7. Site monitoring system
8. Portable repeater

The design is to include:

1. Equipment list with alternatives, ideally using ‘standard’ equipment
2. Schedule of works
3. Evaluation of the system against the design
4. Estimated costs which is evidence based

The following items are out of scope of this document:

1. A secure system for the AFP and Customs.
2. Capacity analysis. It is assumed that the provision of one repeater per site location is sufficient capacity for the intended application.
3. Portable handsets and programming details
4. Integration with radio systems of other parties or audio bridging equipment
5. Site acquisition, access roads, site clearing etc. are the responsibility of IOTA.
6. Training on use of new system
4. Existing Radio Network Architecture

4.1 EXISTING NETWORK TOPOLOGY

The existing network consists of 3 repeaters located on Irvine Hill, South Point and Murray Hill. These repeaters operate on the VHF marine band channels 82, 81 and 80 respectively. The three repeaters can be linked so that traffic being passed by any repeater is broadcast by all others. A secondary repeater operates on channel 21 from Irvine Hill.

An RF combining and distribution network is assumed to exist at Irvine Hill to allow combining of the two channels. During the island visit it was not possible to access the site therefore the exact configuration is uncertain.

Linking between repeaters is via 450MHz point to point radios. It is assumed that audio bridging between E&M interfaces on the radios is used to pass audio between the repeaters, although again the present configuration is uncertain. Figure 1 illustrates the assumed topology of the existing network, including the assumed RF and audio bridging configuration at Irvine Hill.

![Figure 1 Existing network](image-url)
Figure 2 illustrates the RF configuration which was observed at South Point. It is assumed that the configuration at Murray Hill is similar.

![South Point RF Configuration](image)

Figure 3 illustrates the assumed RF configuration at Irvine Hill. It is assumed that transmitter combining and RX multi-coupling devices are utilised.

![Irvine Hill assumed RF configuration](image)
4.2 POWER SYSTEMS

Of the existing sites, Murray Hill and Irvine are mains powered. The actual configuration of the systems is unknown.

South Point is powered using a solar power system consisting of three solar panels, a solar regulator and sealed lead acid batteries. The solar system capacity is uncertain.

4.3 EXISTING COVERAGE

The map shown in Figure 4 represents the coverage provided by the existing 3 repeater sites to the levels defined in the link budget and RF parameters as defined in Appendix A.

The coverage is deficient in several areas because of terrain obstruction and dense foliage losses.
Figure 5 illustrates the dominant server areas of the existing channels
5. Proposed Future Radio Network Architecture

The radio network architecture shall be developed to provide effective and efficient communications for search and rescue operations managed by Indian Ocean Territories Administration. The system shall be designed in a fashion to allow infrastructure sharing by other agencies.

The system architecture shall cater for the concurrent operation of the existing VHF marine repeaters and proposed new VHF land mobile repeaters. The network of VHF marine repeaters shall be operated principally for communications for safety of ships and persons, and movement of ships. The new VHF land mobile repeaters are intended for use by IOTA and authorised representatives, other government agencies and commercial organisations.

The VHF marine repeaters shall continue to operate and provide for wireless maritime communications supporting the wide range of terminals to an international standard. For the support of search and rescue operations the widespread application of VHF marine opens the lines of communications between resources of across many volunteer and commercial organisations.

The proposed new VHF land mobile repeaters shall be linked using UHF point to point single channel links to permit island wide communications. The linking of repeaters shall be configurable in a flexible fashion to allow the dynamic patching of repeater sites across the island. The system shall support the linking of all or a subset of repeaters. This flexibility is valuable for the dynamic management of traffic on the system during times of high utilisation.

The expansion and enhancement of the existing network shall include:

1. Increased coverage
2. Support of connection by multiple agencies
3. Cross-connection of other agencies networks
4. Cross-connection to telephone or mobile phone services
5. Linking flexibility

Figure 6 illustrates the proposed development plan for the network showing the existing site locations and proposed expansion locations. It is assumed that no additional VHF marine repeaters will be installed at upgrade or new sites.
A UHF link is proposed between Rocky Point and the IOTA Office for the purposes of configuring audio bridging equipment from a radio fitted with DTMF keypad and to provide an interface for the proposed phone patch.

At existing sites modifications to the present system will be required to support the proposed new functionality. Modifications to the shelter arrangement may also be required if space limitations exist. Additional feeder tails and a new main feeders will also be required. Audio bridging equipment will be required at all sites to allow the integration of the proposed remote alarm reporting systems.

At upgrade sites, infrastructure such as the power systems, equipment shelters and towers currently exist. The scope of works at upgrade sites will be dependent on agreements made with the other present parties and the site Manager. Use of the any of the existing facilities is subject to availability and agreement by the Owner. Additional approvals may be required is ground works are required.

At new sites, the development process is yet to be started. The scope includes but is not limited to environmental planning and approvals, structural design, ground works, earthing, power systems, access roads, shelters, site establishment and build.
5.1.1 System reliability and availability

For maximum reliability and availability the network shall include redundancy and reliability provisions including:

1. At mains powered sites:
   a. Deep cycle battery backup on grid powered sites dimensioned for 24hr endurance
   b. Redundant (N+1) rectifier configuration

2. At solar powered sites:
   a. Solar/Hybrid or solar with a generator backup power systems including redundancy provisions and designed for the appropriate endurance

3. Lightning and surge protection:
   a. Surge arrester devices on all incoming signal cables
   b. At AC sites surge reduction filters
   c. On solar sites surge arrestors on the feed from the solar arrays to the solar control systems

4. Fully engineered earthing systems including buried earth mats at all new sites to provide maximum protection from potential lightning strikes

5.1.1.1 Spares strategy

To further increase the reliability and availability of the network it is recommended that there be a holding of spare equipment on Christmas Island in order to minimise outage times.

The recommended list of spare equipment to be located on the island includes:

1. One duplexer tuned to suit the entire range of frequencies compatible with the system, or a subset of the frequency range and which can be locally retuned as required. The duplexer can be used as an interim measure to combine TX and RX paths on to one antenna is the case where and antenna of feeder fault affects site coverage. The additional loss offered by the duplexer will affect coverage also, but most probably to a smaller degree than does the fault.

2. One repeater

3. One Diesel Genset

4. One folded dipole antenna

5. One UHF yagi antenna

6. One UHF link transceiver

5.2 COVERAGE EXPANSION

The existing network is comprised of 3 VHF marine repeaters, namely Irvine Hill, South Point and Murray Hill. New VHF land mobile repeaters are to be retrofitted at the existing site locations and additional repeater sites added to provide improved coverage of the island and the surrounding ocean. The locations and feasibility of the new sites provided in subsequent sections should be validated by
the solution supplier. The solution supplier should nominate other site options where they feel there are benefits.

Analysis of the typical radio equipment specifications lead to calculation of a link budget and this in turn defined the minimum signal thresholds for coverage mapping. The RF coverage mapping has been performed using the Atoll design tool using terrain and morphology data sets of the area and a propagation model adapted to the local conditions. The predicted coverage from the extended network is shown in Figure 7.

Figure 8 illustrates the area over which each repeater provides coverage.

Figure 7 Predicted coverage of the extended network
5.3 RADIO SYSTEM CONFIGURATION

The radio system configuration at each site shall be provisioned to allow connection by other agencies and the combining of the existing VHF marine repeaters and the proposed new VHF land mobile repeaters. The RF system schematic provided in Figure 9 illustrates the configuration.

![Figure 8 Best server coverage areas](image-url)
On the transmit path, the radio system shall use a VHF cavity filter transmitter combiner system to allow connection by other agencies to the antenna system. A transmit filter is required to avoid wideband noise from transmitters causing significant desensitisation of the receivers. Filter specifications shall be determined to suit the parameters of the chosen repeater model and allocated channels.

On the receive path, the radio system shall use VHF receiver pre-selector filter and multi-coupler to allow connection by other agencies to the antenna system.

The configuration of the additional repeaters is listed below.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SITE NAME</th>
<th>Co-Ordinates(WGS84)</th>
<th>Structure Height</th>
<th>RX Antenna Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPGRADE</td>
<td>Telstra Rocky Point</td>
<td>-10.4166, 105.67649</td>
<td>40m</td>
<td>35m</td>
</tr>
<tr>
<td>UPGRADE</td>
<td>Telstra Golf Course Lookout</td>
<td>-10.42573, 105.69559</td>
<td>30m</td>
<td>29m</td>
</tr>
<tr>
<td>NEW</td>
<td>Ryans Hill</td>
<td>-10.463635, 105.698634</td>
<td>50m</td>
<td>50m</td>
</tr>
<tr>
<td>NEW</td>
<td>Grants Well</td>
<td>-10.480878, 105.652688</td>
<td>100m</td>
<td>100m</td>
</tr>
<tr>
<td>NEW</td>
<td>South West Point</td>
<td>-10.50714, 105.542784</td>
<td>50m</td>
<td>50m</td>
</tr>
</tbody>
</table>

The connection of additional agencies must be within the frequency range supported by the radio system combiner system components. The radio system combiner shall be provisioned to allow the connection by three other agencies.

The added Agencies are responsible for the supply of a transmitter combiner cavity filter and connection cables for their licenced frequency and integration into the combiner. The agency shall use the next available receiver multi-coupler position.
The following frequency ranges shall be supported. Filters and combining hardware shall be designed
to a maximum of 1dB desensitisation using the worst combination of TX and RX channels.

a. Transmitter Section: 161.6MHz to 164.8MHz
b. Receiver Section: 157.0MHz to 160.2MHz

Agencies connecting to the system must obtain land mobile licenced frequencies in the above ranges
(Segment R/M of VHF high band plan). The ranges above cater for the licenced land mobile channels
which exist in the ACMA database as of June 2015. VHF marine channel 20 is the lowest which is
supported by the system; however, licence conditions do not permit repeater use channels other than
21, 22, 80, 81 and 82.

The receiver multi-coupler shall be configured to operate using the site power supply voltage. The RF
hardware configuration of the system at each site location shall be customised to suit the chosen
channels.

Connection of more than 4 agencies to the system may be possible at the expense of addition
transmit path loss and a need to replace the RX multi-coupler. Evaluation of the system performance
impact should be undertaken prior to attempting expansion beyond 4 agencies.

For the new VHF repeater system the following radio hardware is proposed:

a. 50W Repeater
b. Single folded dipole antennas shall be used to provide separate TX and RX antennas
c. LDF4-50 feeders with LMR400 or similar feeder tail for interconnection between the VHF
   combining equipment and antennas
d. VHF T-pass transmit combiner
e. VHF RX multi-coupler
f. VHF TX and RX filters specified to suit the allocated frequencies

Modifications to the existing site infrastructure may be required to provision the required configuration.
The following site works may be required.

a. Additional main antennas, feeders and tails.
b. Increasing the equipment shelter space to permit additional racks for combining, power
   system and audio bridging equipment or the complete replacement with a new shelter or
   outdoor enclosure
c. Increasing the power supply capacity or replacement of the current power system.

The new folded dipole antenna shall be outrigged from the tower to a distance as specified by the
manufacturer to minimise pattern distortion. Antennas shall be positioned on the side of the tower
where any possible pattern distortion and antenna gain reduction occurs in an area where coverage
overlap exists.

The folded dipole antennas shall be mounted in a co-linear fashion, with the RX antenna in the higher
position. The minimum acceptable vertical separation between TX and RX antenna is 3m. Where
possible, the agreed antenna mounting position should allow for the ability to increase the antenna
separation if required in order to increase the isolation.

An antenna configuration using a binary antenna array mounted on the top of the tower for the receive
path and a side mounted folded dipole for the transmit path may be considered to increase the
coverage. The recommended solution is the use of side mounted folded dipoles at all sites so as to maintain a common inventory and minimise the number of spares parts needed to held locally.

Antennas shall be earthed to the tower at the point of mounting. Feeder cables shall be earthed at the top and bottom vertical runs and at the entry point to the equipment shelter/cabinet and are to be installed as per the as per manufacturer recommendations.

All sites shall be fitted with surge protection on all RF feeders. Additionally surge protection are required to be installed on power and transmission equipment. All surge protection shall be bonded a common site earth.

5.4 REPEATER CONFIGURATION

The ability of the users to hear the repeater tail on key down provides a valuable confirmation that the repeater has sufficient signal from the user(s). This also provides an indication about where coverage exists on the island or at sea and therefore will guide the use of the portable repeater system for deployment for localised coverage when required.

The repeater/repeater controller shall be configured to maintain a hold time of nominally 1 second after the release of the channel by the system users. The hold time shall be configurable.

The RF specifications of the repeaters shall meet or exceed those used in the link budget parameters.

The repeater/repeater controller shall provide the following functions and characteristics as a minimum.

a. Tail bips
b. Anti-Kerchunker Filter
c. Squelch Tail Elimination
d. Repeater time out
e. Alarm input
f. DTMF/CTCSS support
g. Locally configurable RF channel
h. Local O&M interface
i. Local VF I/O, E&M interface
j. N type connectors

5.5 HANDSET FUNCTIONALITY

The existing VHF marine repeater network is compatible with VHF marine band transceivers.

The VHF land mobile repeater network requires the use of radio transceivers which have been programmed to use the licenced VHF channels.
Handsets which support the programming of channels in the VHF marine band as well as the allocated land mobile channels are recommended. This will allow the qualified users to retune between maritime safety repeaters and the land mobile network.

A suggested channel programming strategy includes the programming of:

- VHF marine channels from 1 to 88B or a subset thereof
- The IOTA licenced VHF land mobile channels represented on the radios as channel 90, 91, 92 etc.

Standard VHF marine radios used on vessels will not be able to access channels 90 or above and therefore the logical separation of the two networks is implicitly defined.

The provision of a number of handsets with full DTMF keypad is recommended to allow remote configuration changes of network elements by supervisors or system administrators. Programming may be required to enable supervisor features.

### 5.6 PORTABLE REPEATER

The portable repeater shall be designed to be re-locatable to suit a particular geographic requirement. The portable repeater may be set up for use from a vehicle, on the ground or on-board a maritime vessel. The repeater shall provide additional localised VHF land mobile coverage into areas where the fixed repeaters are not able to reach.

A duplexer shall be installed inside the casing to provide sufficient isolation between the TX and RX signals to allow duplex operation through a single antenna.

The radio repeater unit and duplexer shall be self-contained in a secure and weatherproof transport case. The repeater channel shall be settable using a front panel facility such as a thumbwheel switch or keypad. A front panel switch shall be available to switch the repeater on and off.

To suit operation from a vehicle or boat or using a deep cycle battery the system shall run from 10 – 15V DC. Suitable power cables shall be provided for supplying power to the repeater from the deep cycle battery and to permit charging of the battery from a portable generator or solar system.

#### 5.6.1 RF Performance

The portable repeaters RF parameter shall meet or exceed those used in the link budget. Transmit power should be variable in the range of 5W to 30W or greater.

#### 5.6.2 External connections

External connections for DC power supply and antennas are to be through connectors in the casing. RF connections shall use N type connectors. A power connector appropriate for the consumption of the repeater shall be used. A standard type of connector is preferred.

Short patch cables are to be used internally between radio hardware and the casing connectors so that they may be replaced separately should one of the components be damaged.

Flexible coaxial cable such as LMR400, RG213 or similar to a length of 20m shall be provided for use between the repeater and antenna. The feeder cable shall preferably be provided on a spindle which can be easily unrolled to the required length.
5.6.3 External antenna

The antenna structure shall be portable. The structure shall consist of concentric sections when can be extended to a height of at least 10m. The structure shall be free standing using a tripod extension at the bottom and/or temporary guy wires.

Figure 9 illustrates the high level portable repeater solution.
5.7 FREQUENCY LICENCING

The following limited coast assigned system stations licences currently exist.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>TX Freq</th>
<th>RX Freq</th>
<th>Licence Number</th>
<th>VHF Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irvine Hill</td>
<td>157.05 MHz</td>
<td>161.65 MHz</td>
<td>1623292</td>
<td>21</td>
</tr>
<tr>
<td>Irvine Hill</td>
<td>161.725 MHz</td>
<td>157.125 MHz</td>
<td>1623291</td>
<td>82</td>
</tr>
<tr>
<td>Murray Hill</td>
<td>161.675 MHz</td>
<td>157.075 MHz</td>
<td>1623290</td>
<td>81</td>
</tr>
<tr>
<td>South Point</td>
<td>161.625 MHz</td>
<td>157.025 MHz</td>
<td>1623289</td>
<td>80</td>
</tr>
</tbody>
</table>

Additional limited coast assigned system stations licences will be required if any new VHF marine repeaters are deployed.

5.7.1 Proposed new system licences

The following additional licences will be required:

a. One VHF land mobile licence is required for each of the proposed repeaters at upgrade and new sites. The channels shall be assigned from VHF high band plan segment “R” and correspondingly from segment “M” within the defined frequency range of the system.

b. For the repeater point to point UHF link licences will also be required. Refer to ACMA RALI: Fx17

c. One land mobile licence is required for the portable repeater. There are two possible options for licencing of the channel for the portable repeater.

- Option 1) licence an additional frequency at a repeater site in an area where the portable repeater is anticipated to be used, for example South Point.

- Option 2) Obtain an ambulatory licence in the VHF High band segment R/M.

The most appropriate licencing methodology should be confirmed during the detailed design phase of the project.

5.8 FREQUENCY PLANNING

5.8.1 VHF Marine Repeaters

There are only 5 VHF Marine channels where repeater use is permitted. These channels are 21, 22, 80, 81 and 82. The design of the network on Christmas Island must include a channel re-use plan using only the 5 available channels if expansion to the number of VHF marine repeaters is required.

The existing channels on Murray Hill, Irvine and South Point should preferably remain unchanged to avoid the need to update numerous public databases and maritime information. Figure 10 illustrates one possible frequency re-use strategy. The areas shown in blue and green contours in Figure 10 may experience audio distortion as the result of signals arriving for more than one repeater operating on the same channel.
5.8.2 VHF Land Mobile Repeaters

One land mobile frequency shall be licenced for each of the proposed existing and new repeater site.

Frequency co-ordination needs to be undertaken prior to licence application submission to the ACMA. Intermodulation and site specific frequency characteristics must be assessed to minimise the possibility of system degradation due to spurious interference issues.

5.8.3 Portable Land Mobile Repeater

The portable repeater shall be licenced to operate on a dedicated VHF land mobile frequency.
5.9 Link Network Topology

5.9.1 LINK RADIO CONFIGURATION

A star network is proposed for the linking network with Irvine Hill serving as the main hub site. Initial assessment indicates that most sites have reasonable radio paths to Irvine Hill. All links provide a single analogue voice channel.

![UHF Link Network Diagram]

*Figure 11 UHF link network*

Note the following:

a. No capacity assessment has been undertaken.

b. No link redundancy is proposed.

The radio transceivers used for linking shall be fitted with 4W E&M interfaces which can be used to connection directly to the VHF repeater audio npiut or to an audio bridge. Depending on whether through links and/or other networking connections are required at the site the link radio may be interfaced directly to the repeater or via an audio bridge. Refer to section 7 for details regarding audio bridging.

To allow for possible future upgrade of the link capacity by, for example the use of a MIMO type radios, all link yagi antennas shall be duel pole type. A typical antenna type is the RFI YC4047-13 however other antenna types can be offered.
5.9.2 RADIO LINK DESIGN

The radio path profile of each link shall be assessed. Obstructed paths are acceptable so long as sufficient margin is available and therefore the availability requirement is satisfied.

Links shall be designed for 99.999% availability using the following parameters:

a. Yagi antenna: 13dBi, 10el

b. Feeder: LDF4-50

c. TX power: 1W

d. RX sensitivity: <-117dBm

The proposed linking configuration is shown in the table below. Assessment of the radio path profiles has been undertaken using Pathloss V5. The link feasibility should be validated by the solution supplier during the detailed design. Optimisation of link antenna heights and gains should be completed during the detailed design phase.

<table>
<thead>
<tr>
<th>Link ID</th>
<th>A End</th>
<th>B End</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Irvine Hill</td>
<td>Telstra Golf Course Lookout</td>
</tr>
<tr>
<td>2</td>
<td>Irvine Hill</td>
<td>Ryans Hill</td>
</tr>
<tr>
<td>3</td>
<td>Irvine Hill</td>
<td>Grants Well</td>
</tr>
<tr>
<td>4</td>
<td>Irvine Hill</td>
<td>Murray Hill</td>
</tr>
<tr>
<td>5a</td>
<td>Irvine Hill</td>
<td>Rocky Point</td>
</tr>
<tr>
<td>5b</td>
<td>Rocky Point</td>
<td>IOTA Office</td>
</tr>
<tr>
<td>6a</td>
<td>Irvine Hill</td>
<td>South Point</td>
</tr>
<tr>
<td>6b</td>
<td>South Point</td>
<td>South West Point</td>
</tr>
</tbody>
</table>

Audio bridging equipment is required at Irvine Hill and the sites where through links exist, ie Rocky Point and South Point.

5.9.3 LINK CHANNEL LICENCING

Licences exist for links 4 and 6a, as shown in the above table. Additional licences are required in the 400MHz band, segments Q/U for link 1, 2, 3, 5a and 6b. Licencing shall take place once the site establishment process has confirmed site co-ordinates with survey. Refer to the ACMA RALI: FX17

5.9.4 EARTHING AND LIGHTNING PROTECTION

Link antennas shall be earthed to the tower at the point of mounting. Feeder cables shall be earthed at the top and bottom vertical runs and at the entry point to the equipment shelter/cabinet and are to be installed as per the as per manufacturer recommendations. Where the vertical cable run exceeds 50 metres additional earths shall be installed at the mid-point of the cable run.

All links shall be fitted with surge protection on all RF feeders. All surge protection shall be bonded a common site earth.
6. Site Monitoring System

Network monitoring units shall to be located at each repeater site to signal fault conditions to a central display console. The system shall take a clean contact alarm input and convert this to a DTMF tone for forwarding to a DTMF decoder units which is assumed to be located in the IOTA administration building. A converter unit will decode the DTMF alarm codes and display the alarm on a PC.

Figure 12 illustrates the interface between the network monitoring devices and the central display console.

![Diagram of site monitoring system](image)

**Figure 12 Remote site monitoring**

6.1 FUNCTIONALITY

The DTMF encoder circuit located at each site shall be interfaced to the repeater controller to initiate signalling via the network to reflect the state of changes to the alarm relay/transducer inputs. The alarms requirements per site are to be defined to suit the configuration but shall include as a minimum the following.

1. Power system fault
2. Genset start failure
3. Genset Low fuel
4. Repeater alarm

5. Link radio alarm

The refresh rate of tones sent over the repeater network shall be different during normal operation and fault conditions. The encoder circuit shall initiate the transmission of fault identifying tones more regularly than the status OK tones. The interval between the transmissions of tones shall be adjustable in the range of 1 minute to 360 minutes.

Application software shall be installed on a PC which is to serve as the Network Status Console. The DMTF decoder shall interface with the PC using USB or RS-232. The Network Status Console shall receive messages from the repeater network using a standard portable terminal.

The demodulated audio from the portable transceiver shall be connected to the decoder via a connection cable to suit the speaker/mic port on the radio. The connection to the transceiver shall be removable to allow the transceiver to be used normally if required.
7. Audio Bridge

Audio bridging equipment shall be provisioned at the sites in the network to link audio between repeaters as required. The interconnection of equipment of other agencies to the audio bridging equipment will allow dynamic patching between the connected agencies. The other agencies may be connected to the common repeater hardware or to their own radio infrastructure. Audio bridging shall be made locally at each site or only a central location.

It shall be possible to reconfigure the bridging configuration over the air from a supervisor handset or another terminal which supports DTMF. E&M interfaces are required on repeater and link equipment and equipment of other agencies. Figure 13 illustrates the concept of the audio bridging topology. The arrows illustrate physical connections; logical reconfiguration makes the physical connections active dynamically.

Additionally, telephone interconnect device may be integrated into the audio bridging configuration at one or more sites.
Figure 14 illustrates an audio bridging scenario. Audio bridging equipment is placed at Irvine Hill providing interconnection by Agency 2 who uses their own RF infrastructure. Agency 3 is bridged at Ryans Hill where the agency uses the common RF infrastructure. Connections shall be dynamically activated to suit the requirement at the time, locally via the O&M terminal or using DTMF over the air.

Figure 15 illustrates an audio bridging scenario. Audio bridging equipment is placed at Irvine Hill providing interconnection by Agency 2 who uses their own RF infrastructure. Agency 3 is bridged at Ryans Hill where the agency uses the common RF infrastructure. Connections shall be dynamically activated to suit the requirement at the time, locally via the O&M terminal or using DTMF over the air.
The audio bridging configuration of the system shall allow for the linking of subsets of network sites. Such functionality permits the separation of radio traffic between users located in nearby areas at times when network utilisation is high. The implementation of this feature is dictated by the areas of expected network segments and the bridging configuration per site would need to be designed accordingly during the detailed design.

### 7.1 Phone patch facility

Phone patching to the fixed line telephone network and/or mobile network via DTMF triggered gateway can optionally be incorporated using an appropriate interface device. Phone patch devices may be located at one or more sites. DTMF tones can be used to access individual devices.
8. **Design Requirements**

8.1 **Climate**

Christmas Island experiences a tropical equatorial climate with wet and dry seasons. The wet season is from December to April when the island comes under the influence of the north-west monsoons. During the rest of the year, the south-east trade winds bring slightly lower temperatures and humidity with much less rain.

Tropical cyclones occasionally pass close to the island during the monsoon season, bringing strong winds and heavy rain.

The mean annual rainfall is 1,930 millimetres. Most of this rain falls between November and May.

Humidity ranges between 80 - 90%. The average daily maximum temperature reaches a high of 28° Celsius in April and the average daily minimum temperature falls to 22° Celsius.

Shelters and structures shall be designed, manufactured and installed to withstand cyclonic wind loading as specified by Australian Standard AS 1170 for the applicable Terrain Category of section 4.2.1 in Region B figure 3.1, map.

The supplier shall pay special attention to corrosion protection of the supplied as the islands environment can be very harsh. Additionally the Island can be subject to passing cyclones. Shelters and structures shall be designed, manufactured and installed to withstand the maximum wind loading for the cyclonic classification of the specific geographic area in accordance with AS 1107 and Reference, data from the Bureau of Meteorology.

8.2 **Standards**

The International System (SI) of units is used throughout this Specification in accordance with Australian Standard AS 1000.

Where Australian and International Standards and Specifications are referenced in this document they shall be the current edition with the latest amendments.

Where specifications, standards or any other references in this document refer in turn to other specifications, standards or documents those consequential references shall apply to this specification as if they were completely contained in entirety in the original reference.

<table>
<thead>
<tr>
<th>Standard, Document</th>
<th>Title</th>
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<tbody>
<tr>
<td>AS ISO 1000</td>
<td>The International System of Units (SI) and its Application</td>
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<td>Safety signs for the occupational environment</td>
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<td>Methods for fire tests on building materials, components and structures – Simultaneous determination of ignitability, flame propagation, heat release and smoke release</td>
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<td>Lightning protection</td>
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<td>AS 1580:1996-2002</td>
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<td>Electrical installations – buildings, structures and premises (&quot;SAA Wiring Rules&quot;).</td>
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<td>Stationary Batteries – Valve Regulated Vented Type</td>
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<td>Surge suppression devices for telecommunication applications</td>
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<td>AS/NZS 4417:2009</td>
<td>Marking of electrical products to indicate compliance with regulations.</td>
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<td>AS 4262.1:1995</td>
<td>Telecommunication overvoltages – Protection of persons</td>
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<td>AS/NZS 4680:2006</td>
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<td>Requirements for Customer Cabling Products</td>
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<tr>
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<td>Basic Specification for 19” (482.6-mm) Construction Rack Systems</td>
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<td>EN60950</td>
<td>Safety of information technology equipment</td>
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<td>Dimensions of Mechanical Structures of the 19” (482.6-mm) Series—Part 3: Sub racks and Associated Plug-in Units</td>
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<td>See DIN 41494</td>
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<tr>
<td>ANSI IEEE C62.41</td>
<td>Guide On The Surge Environment In Low-Voltage (1000 V And Less) AC Power Circuits</td>
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<tr>
<td>AS 62040.set</td>
<td>UPS</td>
</tr>
</tbody>
</table>
8.3 Site Earthing

The earthing and bonding at any site, shelter, building or equipment room shall be designed constructed and installed to ensure safe and correct operation of and meet the specifications and performance parameters of IOTA’s items of communications equipment and related control, distribution and power equipment and meeting the minimum specification set out in AS3000.

The Contractor shall supply, install, test and commission a complete earthing system including but not limited to an earthing strip, all required bonds, earth grid and stakes/electrodes around the perimeter of the equipment shelter and the tower, mast or pole base. Earth stakes/electrodes shall be driven into the ground at a sufficient depth to achieve a resistance less than specified for the particular application in Table 1. If the specified resistance is not achieved with this minimum installation the Contractor shall notify IOTA.

The earth electrodes shall be positioned at the cable entry side of the building along the earth perimeter, mast base and each guy anchor point. An earth grid shall be buried parallel to the guy line from each guy anchor and shall be bonded to the mast base earth electrode. An earth strip shall be connected from the building earth grid to the mast base earthing system. The earth strip shall be continued up and be properly fixed to the wall of the building and be extended to the building interior in the equipment room. The earth system mounted up the wall and into the equipment room shall be a copper strip of dimension greater than 2.5mm thickness and 25mm wide.

Where solar array frames are installed, the Contractor shall supply, install, test and commission Earths to the array frames to provide lightning protection specified in section 9 and AS/NZS 3000.

8.3.1 Earth Grid

The earth grid perimeter shall be buried at a minimum depth of 500mm and shall be galvanised steel strip not less than 40mm x 5mm in section. The earth strip shall be bolted to the mast above the concrete footing. An earthing point shall be provided on a vertical member of the mast no more than 1000mm from the top of the concrete footing. The earthing point will contain a 10mm diameter hole to facilitate the connection of the earthing system. It shall also allow ready access for repair and maintenance purposes, whilst maintaining the reliability and security of all the equipment.

8.3.1.1 Inspection boxes

Below ground earth inspection boxes shall be installed near the shelter or cabinet. A bolted earth link is to be used to connect/disconnect the earth strip from the mast electrode to the building earth perimeter.

The Contractor shall design, install, test and commission earth systems requiring minimal (greater than biennially) periodic or routine maintenance or inspections. There are several aspects to the maintainability of earths, including consistency in the earth resistance throughout changes in ambient conditions, ease of maintaining and accessing good electrical connections on the earth connectors and protection against corrosion.

When installed and commissioned, the earthing and bonding system shall be certified by the Contractor to have passed defined tests of parameters in this Specification.

8.3.2 Operating Environment

The area of Works has hot, wet, high humidity summer seasons and erratic rainfall which may be associated with tropical cyclones. The winter season is characterised by clear skies and fine weather.
Underground components of earthing installations are affected by the wet (or dry) soil conditions and high temperatures and shall operate without degradation in performance or shortened life in a temperature range of -10 to 65 degrees Celsius externally. Internal components temperature limits shall be 0 to 50 degrees Celsius.

Above ground components of earthing installations shall be designed, and installed to withstand the wet, humid conditions and cyclonic wind loading as specified by Australian Standard AS 1170 for the applicable Terrain Category 2 of section 4.2.1 in Region A figure 3.1, map.

Normal performance standards shall be maintained under all environmental conditions.

The environmental limits of installations and associated equipment shall be stated. Resistance Values

The Contractor shall ensure that the minimum applicable installed and measured earth resistances appropriate to each type of installation comply with. The table below lists the required resistance for each type of installation.

<table>
<thead>
<tr>
<th>Site</th>
<th>Maximum resistance (ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equipment Earth</td>
</tr>
<tr>
<td>Communications equipment room, Shelter or radio room</td>
<td>2 Ω* (5Ω* with IOTA approval)</td>
</tr>
<tr>
<td>Solar power supply</td>
<td>5 Ω</td>
</tr>
<tr>
<td>Radio pole</td>
<td>5 Ω</td>
</tr>
<tr>
<td>Radio mast</td>
<td>10 Ω</td>
</tr>
<tr>
<td>Radio tower</td>
<td>5 Ω</td>
</tr>
<tr>
<td>Equipment Cabinet</td>
<td>5 Ω</td>
</tr>
</tbody>
</table>

Table 1 – earth resistance
8.3.3 Typical Earthing diagram

Figure 16 Typical site earthing arrangement

8.4 Lightning protection

Each lightning protection device’s earth connection shall be run separately and directly to the lightning protection earth electrode using a 35mm2 or larger green/yellow PVC-sheathed copper conductor. Alternatively, where a series of surge protection devices are co-sited, they may be mounted on a common copper or brass earth bar of not less than 20mm2 cross sectional area. The installation shall be configured so that the earthing conductor-to-earth electrode connection can be removed for testing purposes without removing a surge protection earth.

8.4.1 AC circuits

For sites with AC power a multi stage Transient Discriminating Surge Reduction Filter/s (MSTD-SRF) at least 50KA 8/20 μs peak absorption capacity shall be fitted to the incoming mains feed.

The Surge Filter/s shall be connected into the incoming AC supply as close as practical to the building entry point. The un-protected AC input cable shall be separated from all other cabling by a minimum of 300 mm. Cable connection to the “Protective Earth” shall be a minimum of 6 sqmm cross sectional area.

If failure occurs, the module failure shall be progressive with visual indicators and failure alarm. The SRF module failure alarm shall be cabled to the communications shelter alarm IDF

The recommended surge protection device is the Erico SRF345BS Novaris SFM series surge filters, which are suitable for most IOTA sites, having a low to medium risk of power “surges”.

If the shelter manufacturer wishes to use a surge protection device other than the one recommended it shall perform in accordance with the Earthing Specification and shall be approved by IOTA prior to use.

For high risk sites an Erico TSG SRF363 or Novaris SFH series surge filters or approved equivalent surge reduction filter shall be installed subject to approval by IOTA.
8.4.2 DC sites

At DC sites (solar sites), Lightning protection shunt surge diverters shall be fitted to the interface cabling between the external solar array and the internal power supply equipment. Surge diverters shall be fitted between the solar arrays and inputs to the regulators.

8.4.3 RF connections Surge Protection Devices

All radio feeders that enter a communications shelter or equipment cabinet shall be protected with an in line surge protection device (SPD).

The supplier shall ensure that the selection of appropriate clamping voltage for the SPD considers the total RF power that could be applied to the device

The SPD shall be specified for operation within the anticipated frequency band(s)

The SPD shall be mounted as near as practicable to the shelter gland plate of the cabinet entry plate. The Surge Protection Device shall comply with AS/NZS 1768

8.5 EQUIPMENT SHELTERS AND CABINETS

8.5.1 General

There is requirement for the supply and installation of equipment shelters and external cabinets for the project. Below is the specification for the relevant types

8.5.2 Mains powered shelters

For sites where mains power is available equipment shelters shall be provided as follows:

Mains powered shelters shall have a preferred size with nominal minimum dimensions 2.4 m x 2.4 m x 2.40 m (L x W X H). Depending on individual site specific requirements, other optional sizes may be specified. Mains sites shall be actively cooled with suitably sized split inverter dual head air-conditioners. (Eg similar to Daikin 3MXS52EVMA Mitsubishi Daiya Model SCM45ZA or similar) However the supplier may offer other suitable models of airconditioners

“Environmental” solar powered shelters, if used, shall have nominal minimum internal dimensions 2.4 x 2.4 x 2.40 metres (L x W X H).

The absolute minimum internal height (headroom) shall be 2400mm with 3000mm preferred to enable installation of full height racks and overhead cable trays.

For ease of shipping shelters should preferably be shipped “flat packed”.

8.5.2.1 Walls and Roof

Walls shall be 50mm insulated Colorbond steel and roof shall be 100mm insulated Colorbond steel or similar. External colour shall be white with white internal roof and wall panels.
8.5.2.2 Floor

Floor construction shall include 19 mm termite treated marine grade plywood floors (or 18 mm compressed fibre cement or concrete slab).

The internal floor of the shelter shall be covered with 2 mm thick long life, scuff resistant antistatic vinyl with welded joints.

In accordance with the floor plan, floors shall be capable of supporting the maximum number of fully equipped 48 RU racks/cabinets and battery banks/racks.

The floor loading of the shelter below equipment racks shall be ≥ 6kPa. The floor loading where batteries will be installed (normally 500mm wide along both long walls) shall be ≥30KPa requiring appropriate additional beam strength and flooring thickness.

8.5.2.3 Cable Entries

Single feeder entry apertures of dimensions 600 mm W x 400 mm H at cable tray height shall be installed and fully sealed against the weather. They shall be earthed to the building metal frame.

An external service earth bar shall be provided and mounted externally below the waveguide window. The bar shall be fitted with insulated standoffs. The bar shall be drilled to support a minimum of 10 x double hole earth points. The bar shall be tin plated

An internal service earth bar shall be provided and mounted internally below the waveguide window. The bar shall be fitted with insulated standoffs. The bar shall be drilled to support a minimum of 10 x double hole earth points. The bar shall be tin plated

A 50mm pipe entry shall be provided for carrying the cable from the communications earth electrode system for termination on the Service Earth Bar (Telecommunications) inside the equipment room.

8.5.2.4 External Electrical Supply

All AC mains supply dimensioning, cabling, distribution and installed fittings/GPOs shall be compliant with AS/NZS 3000.

An external mains electrical supply shall be provided to the communications shelter AC Distribution Board (ACDB) from the site transformer or Mains feed line. Where mains power is unavailable, sites shall be solar powered.

Underground electrical cable shall be in Heavy Duty orange electrical conduit complying with AS/NZS 1477. The conduits shall have at least 50% spare capacity after the cables are installed.

The ACDB shall have facility for a power meter and termination of the incoming mains cable on Circuit Breakers/Main Switch isolators.

The ACDB shall be fitted with a multipole changeover switch. The changeover switch shall disconnect the neutral from the MEN link. And shall be capable of being locked in the Off or Generator position. The changeover switch in the Generator position shall connect to an external 240VAC generator switched inlet, type approved by IOTA (eg socket, Clipsal) to readily enable connection of a portable generator during mains power outages.

The maximum anticipated electrical load of the communications room shall be determined to allow the main switchboard circuit breakers and cables to be sized. A minimum capacity of 40A shall be provided.
8.5.2.5 Electrical Safety and Internal Distribution

A Residual Current Device (RCD) shall be fitted for all appropriate 240VAC distribution and protective earthing shall comply with AS/NZS 3000.

Distribution of AC power cabling within the communications room shall be RCD protected and via power ducting or electrical conduit laid separately in the cable trays. Ducting shall be laid from the ACDB to each GPO, devices (eg air conditioners) requiring AC power.

8.5.2.6 Mains Power Outlets

RCD protected 240V AC General Purpose Outlets (GPOs) shall be installed in accordance with AS/NZS 3000 and ACMA requirements throughout the interior of the communications room at convenient locations, mostly for the use of test equipment. At least five GPOs shall be installed, and shall include as a minimum:

1. 2 double GPOs on each of the end walls of the room;
2. 1 double GPO above the surface height of the work table.

All GPOs shall be positioned so that they are not likely to be obstructed by the installation of future equipment.

8.5.2.7 12VDC Power Supplies to Racks

Power feeds for each 12VDC rack shall be a direct connection from appropriately sized circuit breakers within the DC Power, Rectifier, and Battery Rack. The DC cabling shall be carried on the cable tray to each rack and terminated at a 19" rack mounted DC Distribution panel/APDP mounted at the front/top of the rack. The LV cabling shall be separated from the VF, data and RF cabling by at least 50mm.

8.5.2.8 Cable tray

The shelter shall be equipped with overhead cable trays to support cabling within the building

The cable trays shall be a minimum 300mm wide and fabricated from perforated galvanised metal or aluminium. The edges of the cable tray shall be bent up to a minimum of 25 mm and then rolled inwards so that there are no sharp edges on the top or inside of the tray.

The cable trays shall be located such that a ladder can be easily placed below them and allow personnel to run and/or pull cable over them. The cable trays shall be located such that they are positioned over the middle of every existing and future anticipated rack that will be installed in the shelter.

Design and installation of the cable trays, and running of cables within the cable trays shall be in accordance with AS/ACIF S008.

8.5.2.9 Earthing

The site and communications shelter/building earth system shall comply with AS/NZS 3000 and AS3015 (refer also to the earthing section of this document)

The Contractor shall supply, install, test and commission a Service Earth Bar (SEB) in accordance with the AS/ACIF S009.
The SEB shall be clearly and indelibly labelled “COMMUNICATIONS EARTH SEB”.

8.5.2.10 Equipment racks

8.5.2.11 New shelters

Each delivered equipment shelter shall be equipped with quantity 2 x equipment rack as follows:

Racks shall be 600 x 600 x 42RU high

Racks shall be supplied with top covers, front and rear lockable ventilated doors and 2 x removable side panels per rack pair

Racks shall have front and rear 19” support rails installed

An earth system consisting of 1 x vertical Earth Bar shall be installed vertically within in the rear either to the left or the right side of each rack. The earth bars shall be provided pre drilled and tapped to take an M6 screw. The bars shall be installed with insulated standoffs

8.5.2.12 Irvine Hill Site Rack

For Irvine hill a single equipment rack shall be supplied as follows:

Rack shall be 600 x 600 x 42RU high

Rack shall be supplied with top covers, front and rear lockable ventilated doors and 2 x removable side panels

Rack shall have front and rear 19” support rails installed

An earth system consisting of 1 x vertical Earth Bar shall be installed vertically within in the rear either to the left or the right side of the rack. The earth bar shall be provided pre drilled and tapped to take an M6 screw. The bars shall be installed with insulated standoffs

8.5.3 Outdoor cabinets

At sites where these is no AC power available there is a requirement for outdoor cabinets, typically installed at solar powered sites with the following specification;

The outdoor cabinets shall consist of 2x 37 RU x 620 deep cabinets. The cabinets shall be constructed from non-corrosive materials either stainless steel or powder coated aluminium

A single roof is to be provided to cover the 2 x 37 RU cabinets

Each cabinet shall be equipped with 4 x 19” vertical rails to allow equipment to be mounted in the both the front and rear of the cabinets

The cabinets shall be sealed so as to prevent the ingress of water or dust

The cabinets shall be provided with front rear and side sealed lockable doors (keyed alike). The doors shall be equipped with three point locking bars and external lockable handles. The doors shall be of non-corrosive material e.g. stainless steel or powder coated aluminium. Stays or gas struts shall be fitted to the doors so they can be held open
A Removable Gland plate shall be provided in the bottom of each cabinet to allow cables entry to the cabinet. The plate shall be fabricated from aluminium or from steel with an anticorrosive finish.

An earth system consisting of 1 x vertical Earth Bar shall be installed vertically within in the rear either to the left or the right side of each cabinet. The earth bars shall be provided pre drilled and tapped to take an M6 screw. The bars shall be installed with insulated standoffs.

An emergency ventilation system shall be provided for the cabinets for periods of high temperature; 2 x 180cfm 12VDC fans and filters shall be provided in the end doors of the cabinets. For control of the ventilation fans 2 x thermostats shall be provided. The thermostats shall be mounted on the front rails of the cabinets.

For use during maintenance 2 x 12V DC enclosure lights shall be supplied, one in each cabinet. The lights shall be controlled via automatic switches installed on the cabinet front doors.

To simply the installation the contractor shall optionally quote for the supply and installation for prefabricated foundations. The foundations shall be open underneath to allow cables to run into the bottom of the cabinets.
9. **STRUCTURES**

9.1 **Lattice masts**

There is a requirement for 3 x new guyed lattice masts as per below:

1. Ryans Hill 50 metre
2. South West Point 50 metre
3. Grants Well 100 metre

9.1.1 **General**

The design and performance of the mast structure shall be in accordance with the current editions of Australian Standards listed in Section 1.4. The following specific information is provided in order that relevant stability, strength and serviceability states can be calculated.

Where conditions imposed by a relevant Australian Standard are more stringent than the performance requirements detailed below the requirements of the relevant Australian Standard shall prevail.

All masts shall be designed and fabricated for a minimum service life of twenty (20) years with a ten (10) year warranty period for all structural elements.

IOTA towers and masts shall be designed for the following loads:

a. All permanent (dead) and imposed (live) loads
b. Wind loads
c. Earthquake loads
d. Snow and ice loads (where applicable)
e. For guyed masts, permanent and wind loads shall be determined in accordance with AS 3995 However, snow & ice loads and earthquake loads shall be determined in accordance with AS/NZS 1170 (Parts 3 & 4).

Loading combinations shall be in accordance with Section 1.6 of AS 3995 for ultimate and serviceability limit states.

9.1.2 **Mast loading**

The masts shall be designed to carry the following basic load

a. 4 x VHF side mounted dipoles (e.g. RFI SMD20-41 or similar) within the top 20 metres of the mast
b. 4 x UHF side mounted dipoles (e.g. RFI SMD4-67 or similar) within the top 20 metres of the mast
c. 2 x 6m metre VHF binary stacks(e.g. RFI EA80-41 or similar) , 1 out the top of the tower and 1 x offset x 1 metre from the tower within the top 10 metres of the mast
d. 4 x UHF cross pole yagi antennas (e.g. RFI YCP4047-13 or similar) within the top 20 metres of the mast

e. Qty 8 x feeder cables ½ e.g. Commscope LDF4-50 running down the leg(s) of the mast

f. Qty 4 x feeder cables 7/8 e.g. Commscope AVA5-50 running down the leg(s) of the mast

9.1.2.1 Additional mast loading margin

Additional to the above antennas listed above there shall be a 10% additional margin in the design.

9.1.2.2 Mobile coverage antennas

As an option the supplier shall provide the cost for a mast design that accommodates the basic mast load detailed above with the following additional antenna loading being incorporated into the design:

a. 3 x panel antenna (e.g. Kathrein panel antenna model: 80010306) at 120 deg spacing around the mast) within the top 10 metres of the top of the mast.

b. 2x 0.6 m MW dishes spaced at 180 deg spacing within the top 20 metres of the mast

9.1.3 General

The masts shall be of hot dip galvanised steel construction, triangular shape (of equal sides) in plan. Typically the guy wires will be attached at several levels on each leg to outer anchor blocks.

Special attention needs to paid to the corrosion protection of the mast and associated components the tenderer is encouraged to optionally quote for additional mast coatings or treatments which they can demonstrate will increase the service life of the offered masts.

The Client already has in service a stainless steel mast at South Point the supplier is encouraged to consider offering a mast constructed of stainless steel.

The mast shall comply with all relevant Australian standards

9.1.4 Foundation design

All mast foundation designs shall be based on the specific geotechnical information for the mast sites

Geotechnical Investigation

A site specific geotechnical investigation shall be carried out by a qualified and reputable geotechnical engineer. All laboratory testing shall be carried out by a NATA registered laboratory.

The site work shall include a minimum of one backhoe excavated test pit or drilled borehole at or near the proposed tower. The test pit or borehole shall be excavated or drilled below the base of the tower foundation in order to ascertain the condition of the material under the foundation. The geotechnical engineer shall be present on site to instruct the machine operator on the location of and depth of the exploration. When specified, soil resistivity tests shall be carried out.

The geotechnical report shall include, but not limited to, the following:

1. Borehole/test pit log(s)
2. Soil properties, such as undrained or short term strength parameters $C_u$ and $u_0$; bulk unit weight; stiffness values ($E$); internal friction angle

3. Allowable or ultimate end bearing pressures and skin friction (for monopole designs)

4. Observations on water table levels, evidence of settlement or subsidence

5. Soil resistivity test results, when specified

The report shall make recommendations on suitable footing designs for the tower, including suitable founding level. The report shall advise on any precautions during construction (e.g. temporary lining). A copy of the report shall be forwarded to the tower supplier.

At the commencement of foundation works, the contractor’s appointed geotechnical engineer shall be present on site to confirm the actual ground conditions resemble those reported. The tower supplier shall be responsible for the design of the appropriate foundation system based on the geotechnical report provided.

Typically for lattice towers, a foundation may consist of buried pedestals on a large pad footing, drilled piers and rock anchor systems. Guyed mast foundations generally consist of a base pad for the mast and mass concrete anchor blocks for each guy location.

9.1.5 Mast inclusions

The quotation shall include all required guy cables, guy anchors and base foundation rag bolts etc. A Ladsafe or similar climbing system shall be provided

1. A SafetyClimb system shall be included.
2. Anticlimb system shall be included
3. EME signage shall be included
4. A lightning finial shall be included

9.1.6 Shipping

As the masts will be delivered to the island by sea they shall be packaged to be suitable for sea freight in a standard 20ft container.

9.2 Site security fencing

Site security fencing is required at Ryans Hill, South West point and Grants Well sites and shall be as follows:

1. Fencing material shall be Cyclone mesh
2. Barbed wire anticlimb shall be provided around the top of the fence
3. Double access gates shall be provided
4. The fences shall be 6m x 12m x 2m high
5. The fences shall comply with AS1725
9.2.1 Works required shall include:

Supply of all required materials including, but not limited to:

1. Support posts
2. Cyclone mesh
3. Double gates
4. Corner post bracing
5. Barbed wire anticlimb
6. Other materials as required to complete the works

9.2.2 On site works

1. Excavation of holes for the posts
2. Supply of concrete for the installation of the posts
3. Erection of the fencing
4. Clean up and make good the site
5. Connection of the fencing system to the sites earthing network

9.3 Site compound finishing

For new greenfield sites at Ryans Hill, South West point and Grants Well there is a requirement to provide security fencing and to allow ease of access and to remove the risk of wildfire damage to the facility the compound area is required to be finished.

9.3.1 Compound area

Typical compound areas are 10 metres x 8 metres

9.3.2 Clearing

Areas within the proposed compound area shall be grubbed to clean earth and anti-weed matting installed

9.3.3 Finishing

Blue metal/non-combustible ground cover material
9.4 Tree clearing

For solar powered sites Ryans Hill, South Point and South West Point trees shall be trimmed to a distance to allow full sun to solar array. Allowance for tree growth must be considered in the proposed trimming.

Note that approval from the relevant local authorities (Council, National Parks, Land owners) must be sought and granted before any works can be commenced.
10. POWER SYSTEMS

There is a requirement to provide new or to upgrade of existing power systems. There are two types of power systems in the project;

1. AC powered sites
2. Solar

The AC power systems shall consist of a rack mounted chassis with N + 1 rectifier units and separate sealed batteries preferably mounted in the same rack

The Solar systems shall be either pure solar or solar hybrid

The power system shall be provisioned to accommodate the radio equipment and audio bridging equipment either existing and/or provided as part of the IOTA Emergency coverage project.

For other agencies which may connect to the IOTA system or share the sites they shall provide their own power system or appropriately augment the IOTA power system such that the total capacity to cover the total site power load is maintained.

Where appropriate, the power system components such as solar array stands, battery housing etc. shall allow for the accommodation of one or more additional agencies.

10.1 Grid AC Supplied System

There is a requirement for DC power systems as follows:

1. The system shall be nominal 12V DC
2. Systems shall be 19” rack mounted
3. The systems shall be provided with N+1 rectifiers
4. The battery bank shall provide a minimum of 2 days of endurance
5. Initial average base load is 100 watts
6. An upgrade path shall be provided by the addition of rectifier units and batteries to cover system load increase increments of approximately 100 watts (as additional radio systems are added) up to a maximum of 1000 watts
7. A minimum of 2 x battery bank circuit breakers shall be provided
8. The system shall provide, as a minimum, the following clean contact alarms:
   a. AC fail
   b. Rectifier fail
   c. Under Volts
   d. Over Volts.
   e. Load CB trip
f. Battery CB trip

10.1.1 Battery selection

Battery service life is reduced by high temperature and performance is reduced by low temperature. Battery accommodation should ensure a minimum practical service life for sealed cells of at least 10 years at sites with active cooling under the expected site operating conditions.

Temperature compensated charging shall be provided to maximise performance and life.

Battery types shall be limited to sealed, Valve Regulated Lead Acid (VRLA), impregnated fibreglass, Absorbed Glass Matt (AGM) construction.

Batteries shall support a 10-year service life under manufacturers’ standard operating conditions.

All battery banks/strings within the installation shall be of the same nominal capacity.

Cells or battery blocks weighing more than 25Kg shall use mechanical assistance for installation and maintenance.

VRLA cells/batteries can be accommodated within the telecommunications equipment room, complying with AS 2676.2 & AS 3011.2 and shall be accessible to authorised personnel only.

Batteries may be mounted in an open 19” rack, vented cabinets or open stands constructed for the purpose and capable of supporting the total battery weights.

10.1.2 Load centre distribution

The DC power system shall provide an inbuilt load centre with a minimum of 12 x MCB’s – MCB’s to be available in various sizes including 2A, 6A, 10A & 20A alternatively a separate 19” rack top distribution panel can be offered with a capacity of a minimum of 12 x MCB’s. A clean contact CB trip alarm shall be presented as a minimum.

10.1.3 General

The system shall comply with all relevant Australian standards including, but not limited to:

5. The system shall it shall be suitable for operation from nominal 240VAC single phase with a tolerance of plus +10% and minus 20%.
10.2 Off-Grid System

Certain sites do not have access to utility provided AC power hence there is a requirement for packaged skid mounted DC solar power systems as follows:

1. Nominal 12V DC
2. Initial average load is 100 watts
3. Single battery bank to provide 5 days of endurance (assuming solar only with no form of backup)- if the offered system has a backup diesel then the battery backup endurance can be reduced to 2 days
4. Solar photovoltaic panels shall be of monocrystalline fabrication and performance compliant with IEC 60891 and 60904 (AS 2915 withdrawn);
5. PV panel degradation shall be <10% in a life of 20 years
6. Array wiring Solar modules shall be connected in series strings to produce the system operating voltage and then paralleled into groups to form arrays to supply the specified load and recharge currents.
7. If the Control/Regulators do not provide reverse isolation, the design shall ensure that each group of panels has at least one (1) blocking diode fitted to prevent reverse currents entering the module from the battery system or parallel strings of solar modules.
8. The grouping of modules (arrays) shall not exceed the maximum power rating of the controlling regulator.
9. The paralleling of groups into an array shall be via combining terminal connectors which provide convenient disconnect/isolation points allowing testing of the individual strings and arrays.
10. The remaining strings must not be disturbed during testing.
11. The terminal connectors shall be housed in an enclosure providing weather, mechanical, vermin and electrical protection. The construction of the termination enclosure shall ensure condensation can automatically escape.
12. Cabling shall be encased in heavy duty UV stabilised rigid and/or flexible conduit.
13. The Solar control system shall maximise the conversion of solar energy into the communication load and batteries.
14. Maximum Power Point Tracking (MPPT) and accurate regulation systems shall be used.
15. Regulators shall be of the series type giving diode isolation between the solar array and the battery/load.
16. Battery boost or equalising charge systems shall be disabled to prevent damage to sealed batteries.
17. Safety and Warning Signage shall be in accordance with AS 2676.2 and compliant with AS 1319.
18. Total DC system short circuit current and operating voltage-warning signs shall be displayed in prominent locations.
10.2.1 Diesel generator

As these systems are to support the Island’s emergency communications system and at times when the emergency communications is most used is often when the weather is poor and the solar input is low and sites can be inaccessible the Client is most interested in the potential use of a compact diesel generator as part of a hybrid solution or as a backup for the solar.

Note in view of the initially very low power requirement the use of the diesel as only a backup may be sufficient however the supplier is encouraged to provide guidance in their response.

The fuel tank shall provide a minimum of 3 months endurance. If the diesel run time can be such that the endurance could be extended to six months this would be of value however it is expected this may be dictated by the service intervals on the diesel generator.

10.2.2 General design considerations

The tenderer shall pay special attention to corrosion protection of the system as the islands environment can be very harsh. Additionally the Island can be subject passing cyclones. Shelters and structures shall be designed, manufactured and installed to withstand the maximum wind loading for the cyclonic classification of the specific geographic area in accordance with AS 1107 and Reference data from the Bureau of Meteorology

An upgrades path is required, by adding solar panels and batteries to cover the future addition of equipment. The increments are around 100 watts of additional load (as additional equipment is added) to a capacity of 1000 watts shall be provided

The units are to be installed in National Parks therefore the following shall be provided:

1. Silencing to a very low level
2. Fully bunded fuel tank to mitigate the risk of a fuel spill.
3. bunding (catch tray or similar) under the diesel to ensure no polluting of the local environment from a fuel/coolant/oil spill.
4. Special attention shall be given to vermin proofing. The Island has a population of about 40-50 million red crabs which are capable of passing through quite small openings

To reduce the amount of time required to assemble the systems on the Island the units shall be provided as a built up, pre tested packages

The housing shall be such that they can be locked to secure the batteries, diesel and fuel tank and control systems from possible theft or vandalism

The systems shall comply with all relevant Australian standards

As the units will be delivered to the island by sea they shall be packaged to be suitable for sea freight in a standard 20ft container.

The tenderer shall include Factory Acceptance testing of the units in their offer

10.2.3 Remote alarms

The systems shall provide the following alarms as clean contacts:

1. Diesel fail, low fuel warning (20%)
2. low fuel critical (10%)
3. Solar controller fault/fail, battery fault/fail

There is NO requirement for remote current monitoring

10.2.4 Battery selection

Battery service life is reduced by high temperature and performance is reduced by low temperature. Battery accommodation should ensure a minimum practical service life of at least 10 years at sites with active cooling and at least 7 years at sites without active cooling for sealed cells under the expected site operating conditions, ie depending on whether the site is an air-conditioned mains powered site or a solar site.

Operating temperatures in excess of 30˚C may occur in solar sites reducing expected battery service life at these locations.

Temperature compensated charging shall be provided to maximise performance and life.

Battery types shall be limited to sealed, Valve Regulated Lead Acid (VRLA), impregnated fibreglass, Absorbed Glass Matt (AGM) construction.

Batteries shall support a 15-year service life under manufacturers’ standard operating conditions with de-rating under local operating conditions. Note that, this may affect the maximum allowable AH capacity of cells or blocks. Cells designed for the more frequent, deeper discharge at solar sites are heavier than for mains power (rectifier) sites thus individual solar cells have a lower maximum AH capacity than mains sites. (eg OPZv250AH solar compared to 2T275AH mains).

All battery banks/strings within the installation shall be of the same nominal capacity.

Cells or battery blocks weighing more than 25Kg shall use mechanical assistance for installation and maintenance.

Safety and Warning Signage shall be in accordance with AS 2676.2 and compliant with AS 1319.

Total DC system short circuit current and operating voltage-warning signs shall be displayed in prominent locations.

10.2.5 Load centre distribution

A 19” rack top distribution panel shall be offered. Capacity shall be a minimum of 12 x MCB’s

MCBs shall be available in, as a minimum, the following sizes: 2A, 6A, 10A & 20A. A clean contact CB trip alarm shall be presented as a minimum

10.3 Existing site loads

The below are the typical loads for current site:
<table>
<thead>
<tr>
<th>Site name</th>
<th>VHF repeater</th>
<th>manufacturer</th>
<th>VHF repeater model</th>
<th>TX A DC @ 12V</th>
<th>RX A DC @ 12V</th>
<th>TX A DC @ 12V</th>
<th>RX A DC @ 12V</th>
<th>TX A DC @ 12V</th>
<th>RX A DC @ 12V</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irvine Hill (Telstra) - Ch82</td>
<td>Motorola (Spectra Engineering)</td>
<td>MDX1500</td>
<td>11</td>
<td>0.46</td>
<td>90%</td>
<td>10%</td>
<td>Tait</td>
<td>TM80100</td>
<td>1.2</td>
<td>0.35</td>
</tr>
<tr>
<td>Murray Hill (Telstra) - Ch81</td>
<td>Motorola (Spectra Engineering)</td>
<td>MDX1500</td>
<td>11</td>
<td>0.46</td>
<td>90%</td>
<td>10%</td>
<td>Tait</td>
<td>TM80100</td>
<td>1.2</td>
<td>0.35</td>
</tr>
<tr>
<td>South Point - Ch80</td>
<td>Motorola (Spectra Engineering)</td>
<td>MDX1500</td>
<td>11</td>
<td>0.46</td>
<td>90%</td>
<td>10%</td>
<td>Tait</td>
<td>TM80100</td>
<td>1.2</td>
<td>0.35</td>
</tr>
</tbody>
</table>

The above table is based on manufacturer’s equipment specifications and assumptions of system utilisation during an emergency operation period. Validation of the typical load should take place during the detailed design.
11. DC cabling

DC power cabling shall be multi stranded, PVC insulated flexible cable.

In accordance with AS 3015, in -12VDC Telecommunications power systems, the cable colours shall be:

- Red – Positive (Active)
- Black – Negative (Return)
- Green/Yellow (Earth)

The cables shall be double insulated with the outer sheath normally clear to enable ready identification.

Cables installed in parallel supplying the same load or circuit shall be of the same cross sectional area, stranding and length to ensure load balancing is within 1% of any associated conductors within the grouping.

11.1 Cable labelling

The detail below is extracted from the Standard and included as a typical guideline and for information.

Cables shall be labelled at each end stating:

1. Source and destination
2. The fuse or circuit breaker it is fed from and the equipment it is supplying
3. Cable number/s eg. 1/2, 2/2 etc.
4. Communications and Data cables associated with the power equipment (eg for alarm monitoring/supervision and Ethernet connection) shall be labelled with the rack/patch panel number it is fed from and the outlet on which it is terminated.

Labelling shall be permanent. Adhesive labels shall be self-laminating or protected with clear heat shrink tubing. The labelling shall be UV stabilised and clearly visible when installed.

11.2 Cable installation

Cable shall be installed on tray, duct, conduit or other such systems in accordance with AS/NZS 3000, AS/AIF S008, AS 3011 and AS 3015.

Copper crimp lugs shall be used. Connection to dissimilar metals requires conductive jointing compounds to be utilised.

Crimping of lugs greater than 16mm shall be undertaken utilising at least 12 tonne hydraulic hexagon die crimper. Indent crimping shall not be utilised.

Crimped cable shall have the barrel of the lug shrouded with heat shrink tubing of the same colour as the cables outer sheath.
12. Schedule of Works

The proposed schedule of works caters for the works during the 2015/16 and 2016/17 financial years and beyond. The schedule of works considers the cost and time variation between certain build scenarios and suggests a deployment order which aims to allow for improvements during the first year, within the constraints of the existing budget and to allow for future years improvements. Funding may not be guaranteed.

12.1 Tranches

The works has been broken into tranches as follows:

12.1.1 Tranche #1 FY1

Tranche 1 includes:

Upgrade of Irvine Hill with audio patching, new links and VHF land mobile radio equipment. The existing audio link shifted to the land mobile system.

1. Build and integration of Telstra Golf Course lookout site
2. Build and integration of Rocky Point
3. Installation of IOTA Office equipment (Phone patch, bridge controller, NMS display)
4. Site acquisition of South West Point, Ryans Hill and Grant Well site locations.*

At the completion of Tranche 1, the communications system coverage will be extended on the northern part of the island and into Fly Fishing Cove on the VHF land mobile system. The VHF marine repeaters remain in service.

*Site acquisition of all the planned sites is important from the beginning of the project to permit the frequency licencing of all of the sites in the network. Once all the frequencies have been defined, the new portable terminals can be programmed and will not need to be updated. If the site acquisition and frequency allocation does not take place prior to the programming of the terminals, there would need to be more than one terminal programming activity. With only a small terminal base this may not be too difficult to co-ordinate.
Indo-Pacific Territories Administration VHF Emergency Communications System

Repeater Site
Acquired

VHF Land Mobile Repeater

VHF Marine Repeater

Link only site

UHF Link

Figure 17 Tranche #1 network

Figure 18 Tranche #1 network coverage prediction
12.1.2 Tranche #2 FY2

Tranche 2 includes:

1. Upgrade of South Point with audio patching, new link and VHF land mobile radio equipment. The existing audio link shifted to the land mobile system.

2. Build and integration of South West Point site

At the completion of Tranche 2, the communications system coverage will be extended on the northern and southern part of the island on the VHF land mobile system. The VHF marine repeaters remain in service.
12.1.3 Tranche #3 FY3

Tranche 3 includes:

1. Upgrade of Murray Hill with VHF land mobile radio equipment. The existing audio link would be shifted to the land mobile system.

2. Build and integration of Ryans Hill site

At the completion of Tranche 3, the communications system coverage will be extended around the edges of the island on the VHF land mobile system. The VHF marine repeaters remain in service (unlinked).
12.1.4 Tranche #4 FY4

Tranche 4 includes:

1. Build and integration of Grants Well site

At the completion of Tranche 4, the communications system coverage will be extended across the expanse of the island. The VHF marine repeaters remain in service (unlinked).
12.2 Tranche schedule

This sections shows the possible schedule for the project on the assumption that the works would be carried out over successive years.

12.2.1 Tranche #1
<table>
<thead>
<tr>
<th>Site</th>
<th>Type</th>
<th>Task</th>
<th>Duration (Wk)</th>
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<tbody>
<tr>
<td>Rocky Point</td>
<td>Upgrade</td>
<td>Detailed Design</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Site Establishment - Existing Infrastructure</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Construction - Share Existing Shelter, mains power</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commissioning</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Handover</td>
<td>12</td>
</tr>
<tr>
<td>Telstra Golf Course Lookout</td>
<td>Upgrade</td>
<td>Detailed Design</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Site Establishment - Existing Infrastructure</td>
<td>6</td>
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<tr>
<td></td>
<td></td>
<td>Construction - New Shelter, mains power</td>
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<td></td>
<td>Site Establishment - New</td>
<td>12</td>
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<td></td>
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<td></td>
<td></td>
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### 13. Site fit out matrix

The table below gives an indicative equipment summary for each site.

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<td>500 metres guard</td>
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<td>Concrete for building foundations</td>
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<td>Concrete for building foundations</td>
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<td>5</td>
<td>Base station UHF, 19&quot; rack mounted, C/W cabling and shelves</td>
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<td>6</td>
<td>Link radio UHF, C/W mounting shelf and cabling</td>
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<td>4w E &amp; M bridge unit, C/W cabling set, etc.</td>
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<tr>
<td>8</td>
<td>4w E &amp; M bridge unit, 19&quot; rack mounted C/W cabling set, etc.</td>
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<td>9</td>
<td>Existing 36RU, 600x600 C/W front &amp; rear perforated doors, side doors, and forced ventilation</td>
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<td>10</td>
<td>Hockey stick mount for yagi antenna with stay bars</td>
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<td>Lightning arrester/Bulkhead suppressor Hi power N type</td>
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<tr>
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<td>Lighting arrester/Bulkhead suppressor Hi power N type</td>
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<tr>
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<td>Yagi antenna &amp; pole for upper floor cabling connection, mounting kits, etc.</td>
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<tr>
<td>14</td>
<td>Hockey stick mount for yagi antenna with stay bars</td>
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<td>15</td>
<td>Lightning arrester/Bulkhead suppressor Hi power N type</td>
</tr>
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<td>Battery level monitor, 12V, 12RU, control panel, DTMF, interface, alarm function</td>
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<td>Battery level monitor, 12V, 12RU, control panel, DTMF, interface, alarm function</td>
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<td>Equipment rack 2 RU, 19&quot; rack mounted C/W cabling set, etc.</td>
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<td>DC power system, 12V, 600W 2U-AC (ups + 1200W Rectifier), output controller, Solar feed output and 240V Mains, including KG-Multiplexers</td>
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<td>DC power system, 12V, 600W 2U-AC (ups + 1200W Rectifier), output controller, Solar feed output and 240V Mains, including KG-Multiplexers</td>
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<td>Equipment room 2 RU, 19&quot; rack mounted C/W cabling connection, Mounting kits, etc.</td>
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<td>New site surge protection filter for equipment shelters</td>
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<td>Alarm monitoring controller for remote alarm reporting</td>
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<td>Programmable for remote alarm monitoring</td>
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<td>Portable Repeater, cabinet mounted, DC powered, includes cabling, etc.</td>
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</table>

**Figure 25 Equipment summary per site**
14. Budgetary pricing

Below is the budgetary pricing for the project

14.1 Inclusions

Included in the pricing is the following:

1. High level and detailed design.
2. ACMA licencing of all VHF repeaters and UHF link systems
3. Full set of design drawings and calculations including site, tower and tower foundation design
4. Procurement of all equipment as per the site fitout matrix
5. Factory acceptance and system string testing prior to shipping to site.
6. Shipping of all equipment to the port on Christmas Island
7. Installation of all equipment
8. Instation commissioning, hop and system testing of the network
9. Drive testing to confirm the network coverage
10. Produce complete set of test reports
11. Produce as built and final drawings

14.2 Assumptions

The pricing is based on the following assumptions

1. Work would be carried out as per the indicative schedules.
2. The following on-islands works are not included.
   a. Arrangement of Development Applications
   b. Arrangement of landholder and site owner permission and access
   c. Building of access roads and site clearance
   d. Excavation of tower and shelter foundations
   e. No allowance has been made for engagement of an electrical contractor the connection if the new shelters to the local AC supply
3. Geotechnical investigation is included however this assumes that there are suitably qualified engineers and drilling equipment available on the Island.
4. Delivery to site of the larger items e.g towers, shelters, power systems is excluded (We have assumed that it is possible to hire 4 wd ute or tray top vehicles on the island however we have no information on the availability of a large 4 wd truck).
14.3 Budgetary pricing

The Budgetary pricing is as follows:

**Christmas Island full SoW – $3,124,604.71**

Christmas Island scope divided into 4 Tranches

Tranche 1 – $734,859.26  
Tranche 2 – $1,031,737.41  
Tranche 3 – $1,039,579.34  
Tranche 4 – $978,232.17  
Total - $3,784,408.18

Note that the additional costs for the tranche are due to mobilisation demobilisation
15. **Appendix A**

15.1 **RADIO SIMULATION INPUTS**

15.1.1 **Propagation Model**

The prediction model used for production of the coverage maps is the Atoll “Standard Propagation Model” which was tuned for 450MHz signals using calibration data from sites in NSW and QLD. Adjustments to the clutter offsets were made for a 160MHz signals using sample data collected from the existing Irvine Hill repeater. The adjustments resulted in a model mean error of 1.6dB and standard deviation of error of 12dB.

Terrain Data for Prediction
- GDEM2 30m sourced from NASA

Clutter Data for Prediction
- Manually created from Google Earth overlay
- Categories: Sea, Open, Dense Vegetation

15.1.1.1 **LINK BUDGET USED IN SIMULATIONS**

The attached link budget defines the coverage limitations of the system and identifies the link direction which limits the coverage. The coverage contours listed below and shown in the coverage maps match the defined thresholds for Portable Fringe Coverage and Portable Full Coverage.

An additional coverage contour is included to illustrate the usage scenario when the portable radio unit is removed from the belt clip and held away from the user’s body, thereby reducing the signal loss effect of the close proximity of the body.

- Full Coverage = -91dBm
- Fringe Coverage = -99dBm
- Fringe Coverage with reduced body loss = -105dBm

15.1.1.2 **Assumptions**

The following assumptions are made regarding the radio hardware performance and usage scenario.

**Repeater**

1. Repeater TX power of 50W
2. Separate folded dipole antenna used for TX and for RX
3. Transmitter combiner accommodating 4 channels
4. Cavity filter combiner loss = 3.6dB
5. BS feeder assumed 50m LDF4-50, 1.5dB loss
6. RX Pre-selector Filter loss = 1dB
7. Repeater sensitivity from Spectra MX800 specification for 12dB SINAD
8. No account for pattern distortion from tower

User Terminal
1. Portable radio TX power of 5W
2. Portable antenna efficiency of 50%
3. Portable device carried around waist, clipped to belt
4. Body loss reduced by 6dB using outstretched arm
5. Portable sensitivity from ICOM IC-F50V specification for 12dB SINAD
<table>
<thead>
<tr>
<th></th>
<th>Mobile</th>
<th>Portable</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base to User (Downlink)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Station Power Output</td>
<td>47.0</td>
<td>47.0</td>
<td>dBm</td>
</tr>
<tr>
<td>Base Station Combiner/Feeder Loss</td>
<td>5.1</td>
<td>5.1</td>
<td>dB</td>
</tr>
<tr>
<td>Base Station Antenna Gain</td>
<td>2</td>
<td>2</td>
<td>dBi</td>
</tr>
<tr>
<td>User Receiver Sensitivity</td>
<td>-119</td>
<td>-119</td>
<td>dBm</td>
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<tr>
<td>User Feeder Loss</td>
<td>2</td>
<td>0</td>
<td>dB</td>
</tr>
<tr>
<td>User Antenna Gain</td>
<td>2</td>
<td>-0.8</td>
<td>dBi</td>
</tr>
<tr>
<td>User Body Loss</td>
<td>0</td>
<td>10</td>
<td>dB</td>
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<tr>
<td><strong>Maximum Downlink Pathloss</strong></td>
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<td>153.7</td>
<td>dB</td>
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<table>
<thead>
<tr>
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<th>Mobile</th>
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<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>User to Base (Uplink)</strong></td>
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<td></td>
<td></td>
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<tr>
<td>User Power Output</td>
<td>44.0</td>
<td>37.0</td>
<td>dBm</td>
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<tr>
<td>User Feeder Loss</td>
<td>2</td>
<td>0</td>
<td>dB</td>
</tr>
<tr>
<td>User Antenna Gain</td>
<td>2</td>
<td>-0.8</td>
<td>dBi</td>
</tr>
<tr>
<td>User Body Loss</td>
<td>0</td>
<td>10</td>
<td>dB</td>
</tr>
<tr>
<td>Base Station Receiver Sensitivity</td>
<td>-117</td>
<td>-117</td>
<td>dBm</td>
</tr>
<tr>
<td>Base Station RXM/Feeder Loss</td>
<td>2.5</td>
<td>2.5</td>
<td>dB</td>
</tr>
<tr>
<td>Base Station Antenna Gain</td>
<td>2</td>
<td>2</td>
<td>dBi</td>
</tr>
<tr>
<td><strong>Maximum Uplink Pathloss</strong></td>
<td>160.5</td>
<td>142.7</td>
<td>dB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Mobile</th>
<th>Portable</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pathloss limitation</strong></td>
<td>2.4dB UL</td>
<td>11dB UL</td>
<td>dB</td>
</tr>
<tr>
<td><strong>Limiting Path Loss</strong></td>
<td>160.5</td>
<td>142.7</td>
<td>dB</td>
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<table>
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<tr>
<th></th>
<th>Mobile</th>
<th>Portable</th>
<th>DL to Portable</th>
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</thead>
<tbody>
<tr>
<td><strong>Coverage Thresholds for Planning</strong></td>
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<td>Margin for CPC (DAQ-3)</td>
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<tr>
<td>Fringe Coverage Threshold</td>
<td>-116.6</td>
<td>-98.8</td>
<td>-109.8</td>
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<td>LN Fade Margin (90% edge/95% area)</td>
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<td>8</td>
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<tr>
<td>Full Coverage Threshold</td>
<td>-108.6</td>
<td>-90.8</td>
<td>-101.8</td>
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</table>
15.2 UHF link designs

This section sets out the link designs for the UHF point to point links

1. All link designs have been carried out using Pathloss Version 5
2. All designs are desktop studies only

Notes

1. The hop Rocky Point to IOTA office is severely obstructed however as the link is extremely short (1.1 Km) it is anticipated this link will prove reliable.
2. Allowance has been made in the design on all hops as to the heavy tree clutter observed on the visit to the Island
3. It is assumed the existing links, Irvine Hill – Mt Murray and Irvine Hill – South Point have been designed and installed within the standard design parameters.
### 15.2.1 Rocky Point – IOTA office

#### Pathloss Graph

- **Frequency (MHz)**: 45.00
- **Propagation Loss (dB)**: 71.79

#### Antenna Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rocky Point</th>
<th>IOTA Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antenna mode</td>
<td>YB10-xx (TR)</td>
<td>YB10-xx (TR)</td>
</tr>
<tr>
<td>Antenna gain (dBi)</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Antenna height (m)</td>
<td>44.00</td>
<td>10.00</td>
</tr>
<tr>
<td>TX line mode</td>
<td>LDF4-50</td>
<td>LDF4-50</td>
</tr>
<tr>
<td>TX line length (m)</td>
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<td>20.00</td>
</tr>
<tr>
<td>TX loss (dB)</td>
<td>3.58</td>
<td>2.15</td>
</tr>
<tr>
<td>RX loss (dB)</td>
<td>3.58</td>
<td>2.15</td>
</tr>
<tr>
<td>Diffraction loss</td>
<td>71.79</td>
<td></td>
</tr>
</tbody>
</table>

#### Radio Mode

- **Model**: Tat TM9100

#### Receive Signal

- **Rocky Point**: -108.26 dBm
- **IOTA Office**: -108.26 dBm

#### Other Parameters

- **EIRP**: 37.27 dBm
- **Annual multipath availability (%)**: 100.00
- **Annual 2 way multipath availability (%)**: 100.00

**Multipath fading method**: Giga - Barnett
15.2.2 Irvine Hill - Rocky Point

Figure 27 Rocky Point - IOTA Office

Figure 28 Irvine Hill - Rocky Point
15.2.3 Irvine Hill – Ryans Hill

Figure 29 Irvine hill - Ryans Hill
15.2.4 Irvine Hill – Grants Well

Figure 30 Irvine Hill - Grants Well
15.2.5 South Point – South West Point

![Pathloss graph]

**Figure 31 South Point - South West Point**