USER MANNUAL

Cross-Band repeater network

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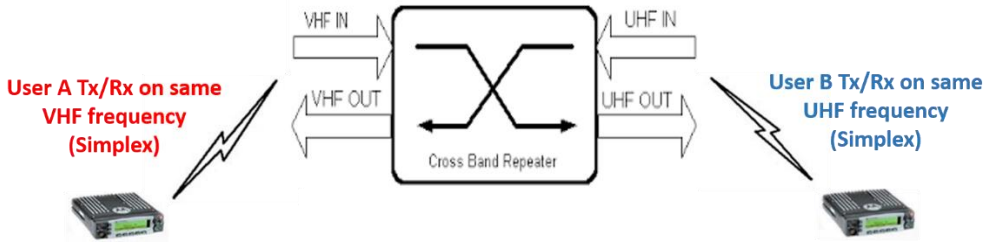
This Manual provides information on the Radio Amateur Cross-Band repeater network, the correct way of accessing the network and how to obtain the maximum benefit from it.

Thanks to all who helped writing this manual.

This document will be updated from time to time as may be required.

(Updated 29/12/2017 by 3B8DU)

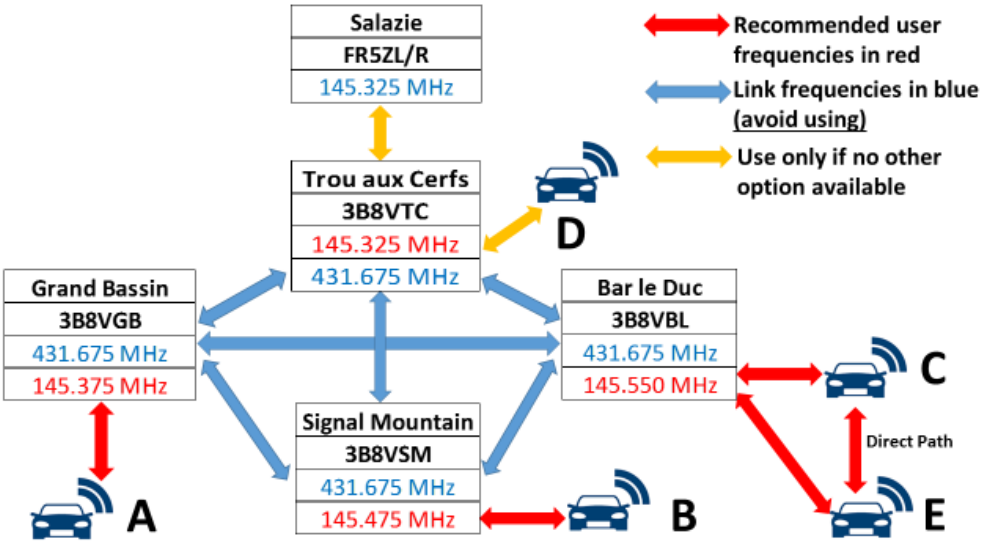
1.0 Cross-Band repeater concept:



On standby the repeater "listens" on both VHF and UHF. If it receives a signal on VHF it retransmit the call on UHF and vice-versa. Several Cross-Band repeaters may be cascaded in a chain or in a mesh to create a network in order to provide coverage over a larger area.

2.0 Mauritius Cross-Band repeater network diagram:

As there is good coverage overlap and UHF propagation for linking the repeaters, a mesh network topology has been chosen. This has numerous advantages over a chain network and make operations simpler.



Note: The direct path scenario is shown as an example and applies to all repeaters (not only to Bar le Duc as shown).

The repeater network schematic of the Association Réunionnaise des Radio Amateurs (ARRA) is provided in Appendix 1.

3.0 Talk path scenarios:

Refer to the network schematic in Section 2.0 above.

a) Mobile A transmits on 145.375 MHz, Grand Bassin repeater repeats the transmission on 431.675 MHz to the other 3 repeaters which repeat the call on their respective VHF frequencies. Thus, all mobiles in Mauritius and Réunion can hear mobile A.

b) Mobile B transmits on 145.475 MHz, Signal Mountain repeater repeats the transmission on 431.675 MHz to the other 3 repeaters which repeat the call on their respective VHF frequencies. Thus, all mobiles in Mauritius and Réunion can hear mobile B.

c) Mobile C transmits on 145.550 MHz, Bar le Duc repeater repeats the transmission on 431.675 MHz to the other 3 repeaters which repeat the call on their respective VHF frequencies. Thus, all mobiles in Mauritius and Réunion can hear mobile C.

d) Mobile D transmits on 145.325 MHz, Trou aux Cerfs repeats the transmission on 431.675 MHz to the other 3 repeaters which repeat the call on their respective VHF frequencies. Thus, all mobiles in Mauritius can hear mobile D.

   In this scenario Réunion mobiles cannot hear mobile D through Trou aux Cerfs repeater, as his transmission is not repeated on 145.325 MHz to Reunion.

   If mobile D is in a high location there may be a direct path to Salazie in Réunion and mobile D may be heared in Reunion. However due to the fact that the direct path to Réunion may not be reliable and may be “one way only” mobile D may cause interference with an ongoing contact in Réunion. Therefore it is not recommended to use Trou aux Cerfs repeater except if there is no other option. The main purpose of the Trou aux Cerfs is to provide a Radio Amateurs link between Mauritius and Réunion networks and also for network redundancy in Mauritius.

e) If a direct path is available between 2 or more mobiles, then, the call is both direct and through the repeaters; for example:

   Direct path: Mobile E transmits on 145.550 MHz, mobile C which is on the same frequency can hear mobile E directly (and vice versa).

   Repeater path: Mobile E transmits on 145.550 MHz, Bar le Duc repeater repeats his transmission on 431.675 MHz to the other 3 repeaters which repeat the call on their respective VHF frequencies. Thus, all mobiles in Mauritius and Réunion can hear mobile E (and C when he transmits).

When the direct path between mobiles in same repeater coverage not possible, then the mobiles must use different repeaters to talk to each other.

f) It is not recommended to access the repeaters by transmitting on 431.675 MHz for the following reasons:

   i) coverage is better on VHF;
   ii) in order for a mobile transmitting on 431.675 MHz to be heard on ALL repeaters, that mobile must be within the UHF range of ALL repeaters at all times. There are not many places in Mauritius where this is likely to happen;
   iii) possibility of creating unnecessary interference to an ongoing conversation (frequent on a chain network);
   iv) UHF frequency is to be used only if no other option is available or for testing purposes with due care taken when the networks is not in use.

4.0 Recommended repeater to be used by region:

Repeaters coverage plots are inserted in Appendix 2 of this manual and may be used to select the best repeater to use in specific locations. Indication per below:

a) West coast from Port Louis to the Morne and lower Plaine Wilhems:
   i) Signal Mountain;
   ii) Bar le Duc;
   iii) Grand Bassin.
b) Upper Plaine Wilhems/ center:
   i) Bar le Duc;
   ii) Grand Bassin;
   iii) Signal Mountain.
c) South East:
   i) Grand Bassin;
   ii) Bar le Duc.
d) East & North East:
   i) Bar le Duc;
   ii) Signal Mountain.
e) North West:
   i) Bar le Duc;
   ii) Signal Mountain.
f) Port Louis & Pailles:
   i) Signal Mountain.
g) South from Souillac to the Morne (poor coverage):
   i) Grand Bassin;
   ii) Bar le Duc.

Bar le Duc is the site with largest coverage.

Detailed repeater network information is provided in Appendix 4.

5.0 Announcements:

Cross Band repeaters cannot have a “tail” like traditional repeater therefore an annoucement has been provided triggered by DTMF Tone 6. This is useful to test and to know if one is within coverage area of the repeaters when no-one available to make a contact.

Please note that the Réunion (ARRA) repeater network uses DTMF tones 1 to 5 and 0. You should be able to trigger Réunion announcements through the Mauritius network as both networks are actually a single larger one. The Réunion network also transmits an announcement at regular intervals giving the repeaters information (callsigns and frequencies).

6.0 User radio settings:

a) Mode FM simplex (same TX and RX frequency).
b) Channel spacing 25 kHz (FM wide).
c) TX CTCSS 97.4 Hz.
d) Scanning (recommended):
   i) stop when Busy;
   ii) delay 2-3 seconds.

7.0 Some operating hints for using the Cross-Band repeaters:

To be heard by all and to avoid causing interference, it is recommended to:

a) use primarily the VHF repeater frequencies;
b) avoid using Trou aux Cerfs (except if you have no other option);
c) avoid using UHF frequencies except if you are in a location where you can access all 4 repeaters on UHF simultaneously or have no other alternative;
d) if you hear someone on a VHF frequency it is generally best to reply on the same frequency;
e) when direct path is weak, use different repeaters;
f) refer to attached coverage maps to select the best repeater to use;
g) identify the repeater you are using as it help other to choose the right one to call back e.g. “3B8XX on Bar le Duc calling”;
h) leave a small blank of about 2 seconds after pressing the PTT before talking, to enable all repeaters to be triggered and to ensure that your first word not truncated and transmitted over the whole network;
i) enabling CTCSS 97.4 Hz on your TX is mandatory to access the repeaters;
j) permanent scanning of all the repeaters frequencies is also recommended.

8.0 Etiquette:

a) Same as with standard practice by Radio Amateurs operators on all bands, one should not transmit on a frequency which is being used so as not to cause interference;
b) ensure that the frequency is not in use for a few minutes before calling, as you may not hear one side of an ongoing conversation, particularly due to the long repeater chain in Réunion;
c) do not trigger announcements or press the PTT unnecessarily as it may be a nuisance others;
d) leave a blank of approximately 2-5 seconds before replying, when in conversation, to give a chance to anyone wishing to join;
e) do not add your own repeater to the network without consultation with MARS as you may create a loop which will block both islands networks. Coordination is essential to avoid interference locally and between the islands;
f) to call simply, announce your call sign and state your presence on the network, so that others on standby know that you are listening and ready to enjoy a contact.

9.0 Appendix 1, ARRA Cross-Band repeater network:

REUNION CROSS-BAND FREQUENCY PLAN (in MHz)

Grand Coude	NDDLP	Les Avirons	La Chaloupe	St-Gilles	Villèle	Le Port	Colorado	ST André	Salazie
FR5FR/R	FR5ZBH	FR5ZBL	FR5ZBK	FR5ZAE	FR5ZBI	FR5ZAD	FR5ZAF	FR1ID/R	FR5ZL/R
145.150	145.175	145.175	145.350	145.350	145.250	145.250	145.225	145.225	145.325
431.100	431.100	431.050	431.050	431.025	431.025	435.100	435.100	431.200	431.200

Source: Above made with information received from ARRA, this is not the official ARRA frequency plan. For official ARRA frequency plan please consult http://www.arra.re or http://www.arra.re/relais-transparents.

a) If you enter a repeater on the red frequency your call goes in direction of the red arrows.
b) If you enter a repeater on the blue frequency your call goes in direction of the blue arrows.
c) Mauritius is presently connected to the Salazie repeater on 145.325 MHz. the users in Réunion use the blue frequencies/path to contact with Mauritius.

Mauritius Frequency Plan (in MHz)

Trou Aux Cerfs	Signal Mountain	Grand Bassin	Bar le Duc
3B8VTC	3B8VSM	3B8VGB	3B8VBL
145.325	145.475	145.375	145.550
431.675	431.675	431.675	431.675

1) The recommended frequencies to use are the red frequencies.
2) If Trou aux Cerfs 145.325 Mhz is used the QSO will not be heard in Reunion, however heard on all repeaters in Mauritius. Use this frequency only if you have no other alternative.
3) The blue frequencies are for linking the repeaters, **do not use** except if you have no other alternative.

Above made with information received from ARRA, this is not the official ARRA frequency plan. For official ARRA frequency plan please consult http://www.arra.re or http://www.arra.re/relais-transparents

For Reunion network:

a) If you enter a repeater on the red frequency your call goes in direction of the red arrows.
b) If you enter a repeater on the blue frequency your call goes in direction of the blue arrows.
c) Mauritius is presently connected to the Salazie repeater on 145.325 MHz. the users in Réunion use the blue frequencies/path to contact with Mauritius.
d) The radio link between St André and Colorado repeaters is weak in the St André to Colorado direction, this situation will be corrected as soon as possible by ARRA.

For Mauritius network:

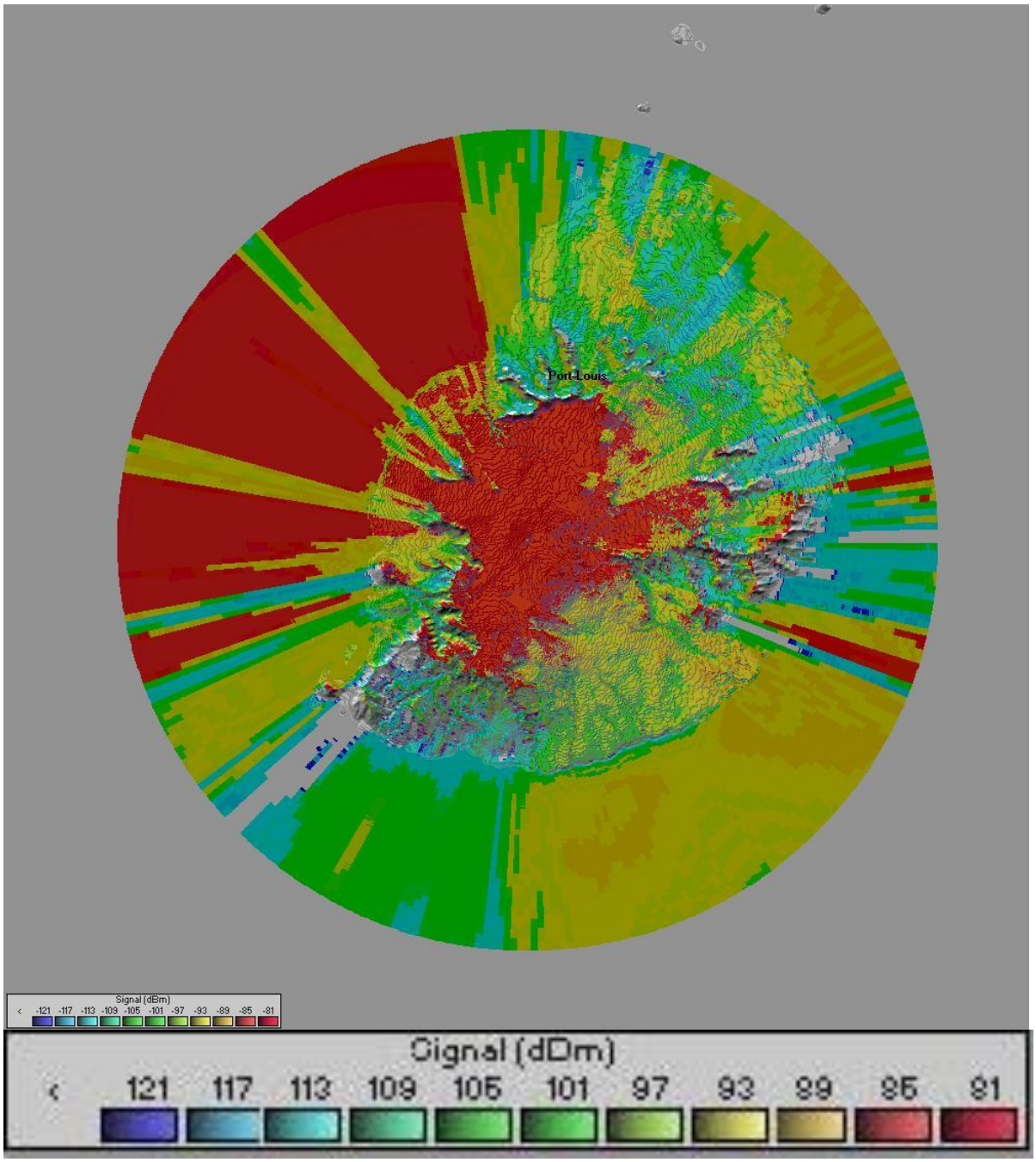
a) If you enter a repeater on the red frequency you call will be heard also on the red frequency and on the **black frequency** at Trou aux Cerfs.
b) The call will enter Reunion network at Salazie and go in the direction of the red arrows to all repeaters in Reunion.

10.0 Appendix 2, coverage prediction plots:

The following mobile coverage plots shows the repeater downlink path. Please note that these are indicative and coverage may be better or worse depending on the station equipment, antenna, power output, feeder length etc.

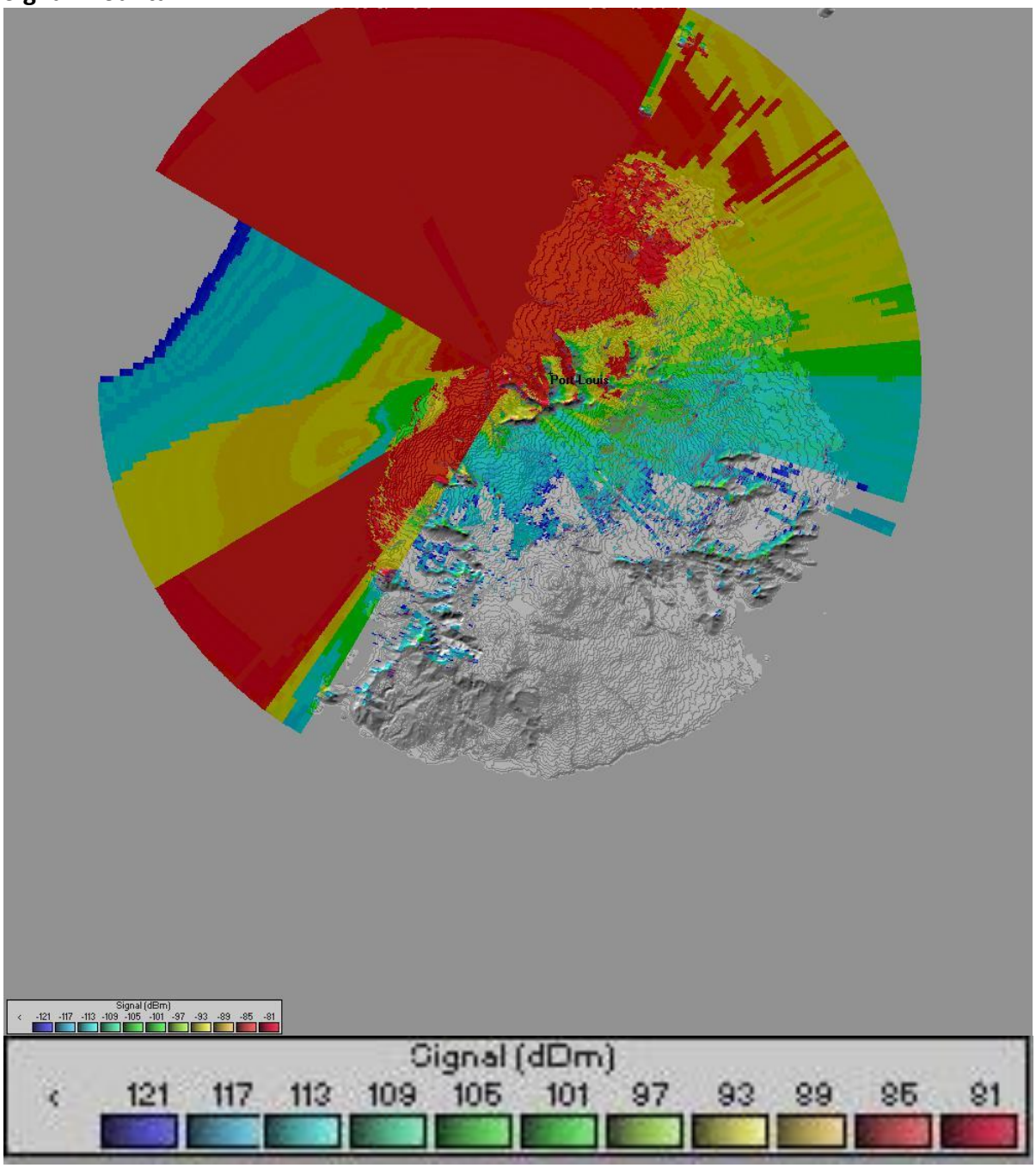
You may produce your own coverage map with your actual station characteristics using Radio Mobile freeware by VE2DBE www.cplus.org/rmw/english1.html. The topographic map is also free.

Trou aux Cerfs VHF:



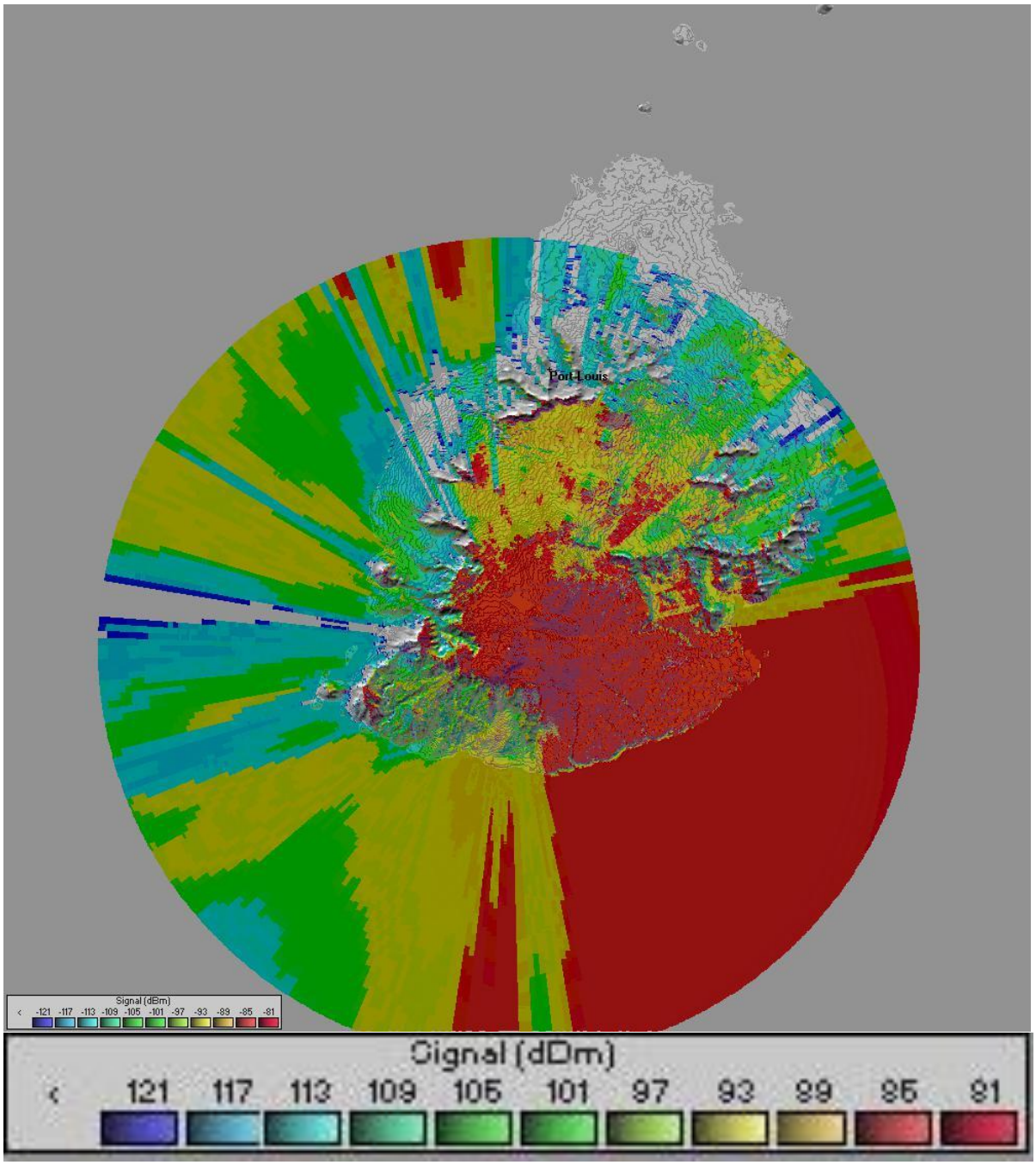
Note: Yellow to Red is S9 and above

Signal Mountain VHF:



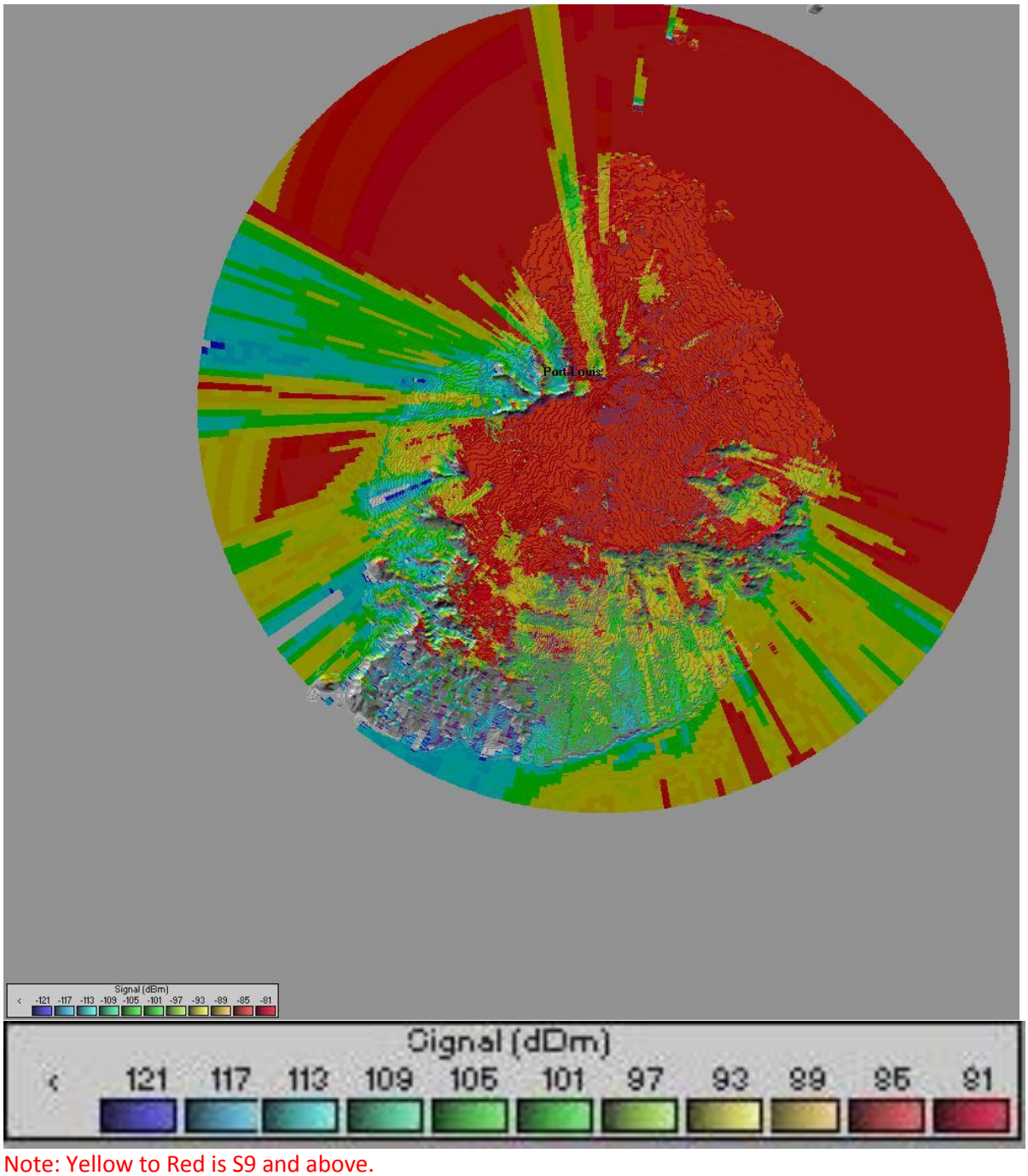
Note: Yellow to Red is S9 and above.

Grand Bassin VHF:



Note: Yellow to Red is S9 and above.

Bar Le Duc VHF:



Note: Yellow to Red is S9 and above.

11.0 Appendix 3, S-Meter to dBm conversion table:

The following table may be useful for converting the S-Meter readings to dBm for prediction plots shown in Section 11 (Appendix 2):

S-points for frequencies above 30 MHz:					
S-Meter reading	**Relative intensity**	**Received voltage**		**Received power (Zc = 50 Ω)**	
S1	–48 dB	20 nV	–34 dBµV	7.9 aW	–141 dBm
S2	–42 dB	40 nV	–28 dBµV	32 aW	–135 dBm
S3	–36 dB	79 nV	–22 dBµV	130 aW	–129 dBm
S4	–30 dB	160 nV	–16 dBµV	500 aW	–123 dBm
S5	–24 dB	320 nV	–10 dBµV	2.0 fW	–117 dBm
S6	–18 dB	630 nV	–4 dBµV	7.9 fW	–111 dBm
S7	–12 dB	1.3 µV	2 dBµV	32 fW	–105 dBm
S8	–6 dB	2.5 µV	8 dBµV	130 fW	–99 dBm
S9	0 dB	5.0 µV	14 dBµV	500 fW	–93 dBm
S9+10	10 dB	16 µV	24 dBµV	5.0 pW	–83 dBm
S9+20	20 dB	50 µV	34 dBµV	50 pW	–73 dBm
S9+30	30 dB	160 µV	44 dBµV	500 pW	–63 dBm
S9+40	40 dB	500 µV	54 dBµV	5.0 nW	–53 dBm
S9+50	50 dB	1.6 mV	64 dBµV	50 nW	–43 dBm
S9+60	60 dB	5.0 mV	74 dBµV	500 nW	–33 dBm

It should be noted that this table shows specifications/theoretical values, in practice many radios S-meter are not accurate and depart from above, particularly at low and high signal strength values.

12.0 Appendix 4, Repeater information:

a) All repeaters:

i) transceiver: Alinco DR-635;
ii) modulation: FM F3E wide mode (25 kHz channel spacing), designation of emission (16K0F3E);
iii) Continuous Tone-Coded Squelch System (CTCSS): 97.4 Hz (RX and TX);
iv) precautions taken to protect the repeaters TX final amplifiers:
    1) additional ventilation: extractor fan on cabinet and fan on transceiver (see photo below);
    2) power output of transceiver will automatically be reduced by half in case of high temperature;
    3) Time Out Timer (TOT) has been set to 300 seconds;
    4) Possible lightning damages is mitigated by gas discharge lightning arrestor, grounding, bonding all elements of the repeaters and all antennas are DC ground.
v) the repeaters are in locked cabinets to prevent any unauthorised tampering, a copy of the keys of active repeaters are in custody of MARS Secretary;
vi) DR-635 operating manual and spare fused have been placed inside the cabinets.

b) Trou aux Cerfs;

i) Callsign: 3B8VTC;
ii) TRX Serial number: M704954;
iii) position: Latitude 20˚19’27.4’’ South, Longitude 57˚31’3.49’’ East ;
iv) height of antenna above sea level: 526 m;
v) feeder loss: VHF3.36 dB, UHF 6.38 dB;
vi) EIRP: VHF 36.70 watts, UHF 25.4 watts;
vii) power supply: Nevada SM23SWI, 23 Amps;
viii) antenna: Diamond X-200;
ix) antenna gain: VHF 6 dBi, UHF 8dBi;
x) electrical supply redundancy: 220 VAC invertor and standby generator;
xi) road access by car: permit required.

c) Signal Mountain;

i) Calsign: 3B8VSM;
ii) TRX Serial number: M704953;
iii) position: Latitude 20°10'30.22" South, Longitude 057°29'33.80"East;
iv) height of antenna above sea level: 297 m;
v) feeder loss: VHF 2.35 dB, UHF 4.55 dB;
vi) EIRP: VHF 46.34 watts, 38.7 Watts;
vii) power supply: Sharman SM23, 23 Amps;
viii) antenna: Sirio SA-270SN;
ix) antenna gain: VHF 3.15 dBi, UHF 5.45 dBi;
x) electrical supply redundancy: 220 VAC invertor and standby generator;
xi) road access by car (4x4 required): permit required.

d) Grand Bassin;

i) Callsign: 3B8VGB;
ii) TRX Serial number: M705242;
iii) position: Latitude 20°24'53.01" South, Longitude 057°29'32.42" East ;
iv) height of antenna above sea level: 702 m;
v) feeder loss: VHF 3.54 dB, UHF 6.79 dB;
vi) EIRP: VHF 45.57 watts, UHF 24.60 watts;
vii) power supply: Sharman SPS1330, 30 Amps;
viii) antenna: Diamond X-200;
ix) antenna gain: VHF 6 dBi, UHF 8 dBi;
x) electrical supply redundancy: standby generator (short power cut before generator kicks in);
xi) road access by car: public, no restriction

e) **Bar le Duc;**

i) Callsign: 3B8VBL;
ii) TRX Serial number: M705241;
iii) position: Latitude 20°12'25.07" South , Longitude 057°35'18.05" East;
iv) height of antenna above sea level: 621 m;
v) feeder loss: VHF 3.97 dB, UHF 7.59 dB;
vi) EIRP: VHF 31.91 watts, 19.23 watts;
vii) power supply: Sharman SPS1330, 30 Amps;
viii) antenna: Diamond X-200;
ix) antenna gain: VHF 6 dBi, UHF 8dBi;
x) electrical supply redundancy: 220 VAC invertor and standby generator;
xi) road access by car (4x4 required): private road, no restriction.

f) **Ventilation:**

Two way radios are normally designed for a duty cycle of around 5% (i.e. 5% transmit time), if exceeding this level the radio will overheat and eventually blowout its final power amplifier. This situation frequently happen when radios constructed for end users are used to build repeaters. In order to avoid same it is essential to dissipate the heat generated by the higher duty cycle when such radios used as repeaters (up to 100% duty cycle).

In order to dissipate the additional heat a fan (as large as the transceiver) has been placed on top of the radios (see photos below). After a one hour test transmission, with the extra fan, the heatsink remained at room temperature.

It should be noted that another fan has been installed to circulate air within the cabinet and for redundancy purpose, also that all sites are air-conditioned (around 24˚ C).

Above temperature issue has been discussed with Alinco Inc. support, they also consider the measures taken (lower power and ventilation) adequate but will not guarantee anything.

Therefore the risk of overheating the radios is considered low, however regular checks to ensure that the fans are working properly needs to be carried out as a routine maintenance.

Signal Mountain repeater:

Thanks to 3B8FP for the photo.

Note also the ferrites on all the cable to the radio to reduce possible local interference being pick-uped by the DC supply and by the microphone lead, as the sites have many Tx from VHF to SHF frequencies.

13.0 Appendix 5, “as made” photographs:

Signal Mountain

Trou aux Cerfs

Grand Bassin

Bar le Duc

14.0 Appendix 6, Acronyms used in this document:

a) **Amps**: Amperes
b) **ARRA**: Association Réunionnaise des Radio Amateurs
c) **ARREG**: Amateur Radio Repeater Experiment Group
d) **aW**: attowatt (10^{-18} watt)
e) **CTCSS**: Continuous Tone-Coded Squelch System
f) **CQ**: code used by Radio Amateurs to make a general call
g) **DC**: direct current
h) **DCS**: Digital-Coded Squelch
i) **dB**: decibel
j) **dbi**: decibels relative to an isotropic radiator
k) **dBm**: decibels of the measured power referenced to one milliwatt
l) **dBµV**: decibels of the measured voltage relative to 1 microvolt.
m) **GPS**: Global Positioning System
n) **Hz:** hertz
o) **FM**: frequency modulation
p) **fW**: femtowatt (10^{-15} watt)
q) **kHz**: kilohertz
r) **m**: metre
s) **MARS**: Mauritius Amateur Radio Society
t) **MHz**: megahertz
u) **mV**: millivolt (10^{-3} volt)
v) **nV**: nanovolt (10^{-9} volt)
w) **nW**: nanowatt (10^{-9} watt)
x) **PTT**: push to talk (usually microphone button used to transmit)
y) **pW**: picowatt (10^{-12} watt)
z) **RX**: receiver
aa) **S**: signal, used to indicate the S-Meter reading
bb) **S-Meter**: signal strength meter
cc) **TOT**: Time Out Timer
dd) **TX**: transmitter
ee) **TRX**: transceiver
ff) **VAC**: volts alternating current
gg) **VHF**: very high frequency, Radio Amateur Band 144 to 146 MHz
hh) **UHF**: ultra-high frequency, Radio Amateur Band 430 to 440 MHz
ii) **µV**: microvolt (10^{-6} watt)
jj) **W**: watt/s

15.0 Appendix 7, Frequently Asked Questions and Answers:

To share knowledge with the maximum of Radio Amateurs, please send any question you may have on the e-mail forum, we will endeavor to reply promptly and update this section accordingly.

Some questions already received from a few Radio Amateurs, during the drafting of this document:

a) **Q1:** *Do I need a dual band radio to use the network?*
A1: No, a single band VHF radio is sufficient. However if a dual band (VHF/UHF) radio is used it is recommended to use the VHF frequencies only. A dual band radio may be useful to carry out UHF tests or to talk to Réunion in some spots where only Trou aux Cerfs coverage available.

b) **Q2:** *Why has the original plan of using a chain network (as in Réunion) been replaced by a mesh network?*
A2: There are many advantages to use a mesh network with Cross-Band repeaters, amongst which are:
i) as UHF has a smaller footprint, a mesh network unable usage of VHF on all the repeaters thus provided an overall better coverage;
ii) a call initiated on VHF through any repeater in the network is repeated through the UHF links to the other repeaters which retransmit same on VHF. This is not the case with a chain network as one need to constantly switch between VHF and UHF depending on location;
iii) in case of failure of one repeater in a mesh network all the other repeaters can continue to operate and are still linked to each other. In a chain network any repeater failure will result in the chain being broken, thereby cutting the network in two and causing much more disruption to the traffic;
iv) shutting down one repeater for any reasons such as interference or maintenance create less disruption;
v) simpler frequency management, more spectrum efficient than a chain network;

c) **Q3:** *Using same the frequency on UHF on several repeaters may create "zero beating" interference, therefore synchronization (such as GPS/precision clock source) may be required?*
A3: Zero beating interference occurs when two or more transmission present simultaneous on same frequency (used in simulcast networks). Any slight difference in frequency or phase at the receiver end creates distorted audio and noise. This will not occur in normal usage on the Mauritius Cross-Band repeater network for the following reasons:
i) simplex is used for communication, therefore only one repeater transmit on the common UHF frequency at any point in time;
ii) VHF channels use different frequencies there is no possibility of "zero beating" interference occurring;

iii) precise clock source would have been required in case of simulcast (repeaters transmitting on same frequency at the same time).

d) **Q4***: Why using CTCSS? It's is a pain to set.*

A4: As the sites used by the repeaters are well suited for Private Mobile Radio (PMR) service, Cellular, fixed radio links etc., there are many non-amateur operators using these sites and spectrum pollution is quite high. Many intermodulation products are present, some of which fall within the Radio Amateurs' bands. Therefore, CTCSS is used to reduce unnecessary triggering of the repeaters in case of interference from these other on-site services.

It should be noted that the repeaters also transmit CTCSS (97.4 Hz) and this may be used also on the mobile. It may be useful if one is near a transmitter station such as cellular, police etc. which may be creating high radio noise level and opening unnecessarily the squelch.

d) **Q5***: As using the UHF frequency is not recommended, why not preventing access on the UHF links by using a "secret" CTCSS Tone or DCS Code?*

A5: There may be situations when one wishes to use the UHF frequency:

i) to experiment with antennas, do coverage tests etc..

ii) in some spots where only Trou aux Cerfs coverage is available (quite rare cases), one may want to contact Réunion and has no other alternative than using UHF.

In the above cases, the UHF station operator will have to be cautious so as not to cause undue interference to other users of the network. Furthermore, the UHF operator runs the risk of receiving interference from other users of the network who are unaware of his/her presence on UHF.

g) **Q6:** *What antenna should I use at my fixed location?*

A6: An omnidirectional antenna is recommended so that you may be able to use the direct path also. Thanks to the good coverage of the 4 sites there is no need of high gain antennas. A simple ¼ wave vertical should be sufficient in most cases.

h) **Q7:** *Will coverage for portables such as the Baofeng UV-5R be good?*

A7: The coverage obtained with such portables has been found to be excellent, particularly when used with a gain antenna both at a fixed location and during mobile operations. However in the finge areas or when moving a higher power is recommended.

g) **Q8:** *Can the repeaters be used for communicating other modes than in voice?*

A8: Yes, any mode using the audio bandwidth can be used, such as SSTV and packet. SSTV has been used successfully, both locally and between the islands.

h) **Q9:** *How to use the network in case of an "emergency"; what constitutes an emergency? Who declares it and what to do if an "emergency" is declared that requires exclusive use of the network by certain persons/entities?*

A9: MARS is a stakeholder in the national project called National Multi-Hazard Early Warning and Emergency Alert System (EWEAS) which is to be implemented by the Government. Radio Amateurs are expected to contribute to this National plan and be part of it.

MARS or a group under the aegis of MARS will have to establish formal procedures and modus-operandi for emergency situation for Radio Amateurs involvement (including the Cross-Band repeater network use).

Coordination with Réunion will also be essential as they already have such plan in place and do rehearsals from time to time using their repeater network.

i) **Q10:** *My radio does not have has some CTCSS tone particularly the 97.4 Hz one ?*

A10: Unfortunately some old radios does not have CTCSS at all or a limited number od CTCSS tones. An external CTCSS Tone Encoder may be used.

The 97.4 Hz tone was already in use in Reunion prior to implementation of the 3B8 network, therefore same was chosen so that we may have a common network.