|  |
| --- |
| Proposed New Device Boundary  Criterion Methodology |
| Radiocommunications (Unacceptable Levels of Interference) Determinations  Schedule 1: Location of a transmitter  Schedule 2: Device Boundaries  Schedule 3: Ground and antenna height |
| August 2011 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Canberra**  Purple Building  Benjamin Offices  Chan Street  Belconnen ACT  PO Box 78  Belconnen ACT 2616  T +61 2 6219 5555  F +61 2 6219 5353 | **Melbourne**  Level 44  Melbourne Central Tower  360 Elizabeth Street Melbourne VIC  PO Box 13112  Law Courts  Melbourne VIC 8010  T +61 3 9963 6800  F +61 3 9963 6899 | **Sydney**  Level 5  The Bay Centre  65 Pirrama Road  Pyrmont NSW  PO Box Q500  Queen Victoria Building  NSW 1230  T +61 2 9334 7700  1800 226 667  F +61 2 9334 7799 |  |  | |
| © Commonwealth of Australia 2011  This work is copyright. Apart from any use as permitted under the Copyright Act 1968, no part may be reproduced  by any process without prior written permission from the Commonwealth. Requests and inquiries concerning reproduction  and rights should be addressed to the Manager, Communications and Publishing, Australian Communications and Media Authority,  PO Box 13112 Law Courts, Melbourne Vic 8010.  Published by the Australian Communications and Media Authority |

Introduction 2

The device boundary criterion 2

Device boundary methodology 5

Schedule 1 Centre location and effective radius of a transmitter 5

Schedule 2 Device boundaries 6

Schedule 3 Effective antenna height 9

Conclusions 11

Annex A - Proposed methodology 12

Schedule 1 Location of a transmitter 12

Schedule 2 Device Boundaries 13

Part 1 Device boundary of a transmitter 13

Part 2 Device boundary criterion 13

Part 3 Calculation of Propagation Loss 14

Schedule 3 Ground and antenna height 15

Part 1 Average ground height 15

Part 2 Vincenty’s Formulae 17

# Introduction

The section 145 determination sets out what is an unacceptable level of interference caused by a transmitter operating under a spectrum licence, issued in the appropriate band, so as to ensure that high levels of emission from transmitters operated under a licence are kept within the geographic area and frequency band of the licence.

A level of interference caused by a transmitter operated under a spectrum licence issued is unacceptable if the operation results in a breach of a core condition of the licence, the specified deployment constraints are not adhered to and/or if any part of the device boundary of a transmitter lies outside the geographic area of a licence.

Before a device can be registered under a spectrum licence, in most cases, the device boundary of the transmitter must be calculated in accordance with the relevant determination made by the ACMA under section 145 of the Act. This is referred to as the device boundary criterion (DBC). The Schedules of the section 145 determination are written to allow licensees to determine the device boundary of a transmitter such that if any part of the device boundary lies outside the geographic area of the licence, the transmitter is deemed to cause unacceptable interference.

The current methodology for the calculation of the device boundary was developed for the first spectrum licences issued nearly 15 years ago. It is based on a segment/sector arrangement for calculating the distance along each radial from the transmitter to the point where the device boundary criterion is satisfied. This process results in the creation of the device boundary of the transmitter which must be entirely within the geographic area of the licence for the transmitter to be deemed not to cause unacceptable interference under section 145 of the Act.

Although it has worked fine as a means to manage interference across the geographic licence area, the availability of increased computing resources, the identification of implementation inconsistencies across varying frequency bands and updates to recognised propagation models means that it is worth visiting the procedures of the section 145 determination and calculation of the device boundary criterion with the aim to simplify and align each of the frequency bands to a common device boundary template. This paper presents a new methodology for the calculation of the DBC which aims to reduce some of the complexities associated with the current implementations as well as facilitating better representation of the interference boundary of a transmitter by densifying the number of radials and increments at which the DBC is calculated.

The methodology in this paper is the baseline method to be implemented in each of the spectrum licence bands currently being considered by the technical liaison group (TLG). This paper does not discuss issues that are specific to frequency bands, and for that reason, some parts of the Schedules are not entirely complete; this includes what propagation model or level or protection is applied to a particular spectrum licence band, whether or not a scaling parameter is required – those discussions are part of the main TLG discussion paper relevant to each band.

## The device boundary criterion

The DBC and the calculation procedures typically contained in a section 145 determination are used to create ‘buffer zones’ at the geographic boundary to manage in-band interference between area adjacent services. The device boundary is the distance from a transmitter to the point where the signal drops below a level that could cause interference to receivers in adjacent geographical areas.

An important consideration is what the device boundary calculation is intended to achieve; it should be realised that it is not used to estimate the coverage of a particular base station, but a mechanism that is used to determine if emissions from a device are contained within the geographic boundary of a spectrum licence and indirectly determine the potential interference area of a base station that can then provide protection to adjacent area licensees by the creation of “buffer zones”. There have been very few reported cases of the DBC not providing effective protection to adjacent area licensees; however, many licensees have noted that the DBC does not allow deployment close to the boundary because of the “dead zones” created.

There are options available to licensees when proximity to the geographic boundary is an issue, including the use of guard space or obtaining agreement from the adjacent area licensee. Information on how to register a device using guard space or agreement are detailed in the *Radiocommunications Advisory Guideline (Registration of Devices under Spectrum Licences without an Interference Impact Certificate) 1998*.

The specified level to protect receivers in the adjacent geographic area is determined by setting a benchmark level of protection (LOP) that should be met. This LOP is generally based on an analysis of the most likely technology or technologies to be deployed in the band.

If the device boundary calculation results in the transmitter’s device boundary falling outside the geographical area of the spectrum licence, the device can only be registered through the use of guard space or agreement. Figure 1 shows the dead zone created at the licence boundary as a result of the DBC. It assumes that the transmitter is pointing toward the boundary and hence there will be an area surrounding the boundary where base transmitters are unable to get any closer.

Licensees can place a base station near the boundary and face antennas back into the licence but this may be difficult to manage, as in areas where licence boundaries are located, operators typically deploy at strategic locations to optimise coverage, like the largest hill in the area. The device boundary criterion also doesn’t allow licensees to get any closer than one segment away from the boundary due to its calculation methodology; in some bands this can be as much as 5 minutes of arc (or approximately 9 km). The application of such large segments can also have a significant effect on whether devices further from the boundary pass or fail the DBC.

|  |
| --- |
| Figure 1 “Dead zone” at the geographic boundary |
|  |
|  |

“Dead zones” occur at the geographic area boundary because in many practical cases the receiver needs to be located away from the geographic area boundary such that it can maintain an appropriate C/I ratio. Therefore, if the interference area caused by the transmitter is greater than the coverage area, a “dead zone” results.

It therefore may be useful to examine methods to reduce the size of the “dead zones” created by the application of the DBC such that licensees can make best use of their spectrum licence geographic area. The equivalent situation applies to adjacent area licensees that must also meet the DBC.

# Device boundary methodology

The current device boundary methodology is based on a segment/sector arrangement whereby the terrain height in each segment is averaged. The average terrain height per segment is used to calculate the effective site height of the antenna which can then be used in the appropriate propagation model to calculate the path loss between the transmitter and the segment/sector; this is the procedure used to calculate the device boundary.

|  |
| --- |
| Figure 2 Segments and Sectors |
|  |
|  |

An issue that arises with the use of this procedure is that the level of terrain averaging over each segment/sector increases for each segment increment along each of the radials. In addition, the method to determine the data that should be included in the averaging is potentially complicated.

This section of the paper will focus on the current device boundary criterion template and those parts of the section 145 determination schedules that are consistent across the frequency bands already spectrum licensed in Australia. For those parts of the schedules where the methodology differs from the template, details of proposed inconsistencies, changes or improvements to be made, will be given in the appropriate technical liaison group paper on a case-by-case basis.

A full description of the proposed device boundary schedules of the section 145 determination is given in Annex A. This description forms the baseline template for the schedules of the section 145 determination, and is proposed to be implemented on all future spectrum licences that require calculation of the device boundary.

## Schedule 1 Centre location and effective radius of a transmitter

The centre location of a transmitter allows the licensee to determine the location, by reference to the appropriate datum (currently, the referenced datum is either the Australian Geodetic Datum 1966 or Australian Geodetic Datum 1984), the latitude and longitude of the phase centre of the transmitter (or group of transmitters).

The effective radius of a transmitter allows a group of transmitters, within a specified radius, to be registered as a group, with the effective radius added to the result of the device boundary criterion to form the device boundary of the transmitter. The effective radius is most prominent in the registration of groups of transmitters using the towns mobile list or roads mobile list, which identified locations by latitude and longitude, with an appropriate effective radius that would allow licensees to deploy transmitters within the core conditions of the licence inside the effective radius.

In reviewing registration options under spectrum licences, it was found that use of the towns and roads mobile list is not high, but most importantly, that the definitions contained in the towns and roads mobile list have not be updated on a consistent enough basis to keep track of changes in the status of locations in those lists or the need for any additions or deletions.

One of the other issues with the towns and roads mobiles list is that it does not require each individual transmitter within the effective radius of each location to be registered, meaning that the ability for others, including the ACMA, to conduct detailed interference management or simply compile statistics of device registration numbers in certain areas becomes more difficult to achieve.

As a result, the ACMA proposes that the use of the towns and roads mobile lists for spectrum licensing be removed from future section 145 determinations – this means that each individual transmitter will require registration. It does not however preclude licensees from registering group transmitters on the same physical structure or those that are part of distributed antenna systems, including leaky-feeder type systems.

The proposal to remove the towns and roads mobile lists also means that the requirement for an effective radius to apply in certain group transmitter registration cases ceases. This is because there are no cases where an effective radius can be considered a requirement to calculate the device boundary.

The result of the proposed changes to Schedule 1 of the section 145 determination are shown in Schedule 1, on page 12.

## Schedule 2 Device boundaries

As detailed in the section The device boundary criterion on page 2, the device boundary criterion is the calculation procedures typically contained in a section 145 determination and are used to create ‘buffer zones’ of reduced emission levels across the geographic boundaries of the spectrum licence. To calculate the device boundary, the distance between the transmitter is calculated to the point where the received signal level drops below a level that could cause interference to receivers in adjacent geographical areas.

The current procedure calculates the device boundary at X-minute increments in distance along each of Z-radials. The current values for these parameters for various spectrum licences is summarised in Table 1.

|  |
| --- |
| Table 1 Summary of parameters used to calculate device boundaries for various spectrum licences |
| |  |  |  | | --- | --- | --- | | **Spectrum Licence Band** | **X-minute increments** | **Z-radials** | | 800 MHz | 5 | 72 | | 1800 MHz | 5 | 144 | | 2 GHz | 1 | 144 | | 2.3 GHz | 5 | 144 | | 3.4 GHz | 5 | 144 | |
|  |

Table 1 indicates that different combinations of increment and radial parameters have been used to define the device boundary calculation for difference spectrum licences.

This has meant that there is an inconsistency in the procedures across different bands, resulting in varying averaging effects when calculating the effective antenna height (the procedure to be discussed later).

One of the other concerns is that the density is not sufficient enough, meaning that the device boundary is not taking into account an appropriate number of radials and associated segments which creates a course device boundary. At large increments, the segment size is appreciably big such that the averaging effect of the effective antenna height calculation does not accurately consider the actual elevation of the point of a notional receiver. For example, the approximate area of the first segment for a 1-minute 2.5 degree radial is 0.07 km2; the approximate area of the last segment (segment 55 utilising 1-minute increments), is 8.11 km2.

Another issue with having a course increment along the radials is that the closest a licensee can deploy to the boundary is the increment length, that is, 1 minute (approximately 1.8 kilometres) or 5 minutes (approximately 9 km).

As a result, the ACMA proposes that all future section 145 determinations utilise a denser increment and radial structure to limit the averaging effect of effective antenna height and to also allow licensees to deploy closer to the boundary, of course, noting the utility of ‘dead zones’ which will ultimately mean there is nominally a setback from the geographic boundary.

The proposal is to decrease the increment length to 500 metres and increase the number of radials to 360. This level of densification has been chosen because firstly, 500 metres is equivalent to the length of two DEM cells of which elevation data is taken for effective antenna height, and secondly, 1 degree radials have been chosen because it is thought that any further densification would most likely result in interpolation of antenna patterns resulting in no more information of importance to the device boundary.

Converting increments to metres rather than minutes also means that the actual length of each radial is consistent for varying latitudes. The variation in a one degree length of longitude at Darwin (108.58km) compared with Hobart (81.25km) is over 25 km. This effectively limits the range of the device boundary criterion in the southern latitudes compared with the northern areas.

To enable calculation of distance over the spheroid, the Geoscience Australia Technical Manual recommends use of the Vincenty Method of calculating distances over spheroids, and as a result, this method is provided in Part 2 of Schedule 3 in Annex A.

The TLG Reference Paper – *GDA94 Adoption* details the ACMA’s proposed adoption of the Geocentric Datum of Australian 1994 (GDA94) as the datum for spectrum and apparatus licensing. As a result of the potential change to GDA94, the Australian Spectrum Map Grid and DEM will be updated accordingly.

Under the current methodology, each latitude and longitude end point for each radial is identified by reference to the spectrum map grid to find the device boundary of the transmitter with respect to its geographic licence boundary.

By drawing a line through the end points of each radial and identifying the individual DEM cells that are cut by this line, a block outline of the device boundary can be formed, consisting of spectrum map grid cells that can then be used to check if the device boundary of the transmitter lies within the geographic licence boundary.

This procedure works well for the current methodology because the radials and increments are sufficiently coarse that the boundary may span a number of spectrum map grid cells before an end point exists. By reducing the increment spacing to 500 metres and increasing the number of radials to 360, the likelihood of adjacent spectrum map grid cells not containing and end point is greatly reduced.

Therefore to reduce the complexity of calculating the device boundary, it is proposed that there is no need to identify end points with respect to the spectrum map grid. The ACMA believe with the new methodology that it is actually only a requirement that the end points calculated along each radial are within the geographic area of the licence (in this case, the end points constitute the device boundary). This is a requirement for determining what is unacceptable interference; that is, if any part of the device boundary of the transmitter lies outside the geographic area of the licence the transmitter is deemed to cause unacceptable interference, as specified under clause (7) of the section 145 determination.

This procedure is detailed in Part 1of Schedule 2 in Annex A.

The device boundary of a transmitter is typically established as the value of the expression RP-MP, where RP is the horizontally radiated power for each bearing and MP is a combination of path loss, level of protection and the notional receiving antenna gain including feeder losses.

The horizontally radiated power is currently provided by licensees when they register each device and consists of the horizontally radiated power in EIRP dBm per 30 kHz, typically at an elevation angle of 0 degrees even though antenna tilt can be taken into account.

The ACMA has found though that device registrations do vary in their implementation of what the horizontally radiated power is meant to be, and its appropriate units. The definition of the horizontally radiated power needs to be strengthened to ensure that it fully defines what is required of licensees when they register. It is also important to stress that the EIRP information being provided to the ACMA be in appropriate units, that is, EIRP dBm per 30 kHz.

Another consideration is the effect that beam-forming antennas may have on the role of the device boundary criterion. Beam-forming antennas have the ability to concentrate more power in specific directions because the gain of the phased antennas can be directed.

Licensees should register their horizontal radiated power patterns such that it takes account of any potential performance gains that may be obtained through the use of beam-forming. Therefore, the horizontally radiated power pattern will include, for all azimuth angles, the maximum potential EIRP achievable utilising beam-forming so that calculation of the device boundary considers this.

The value of MP is a combination of path loss, level of protection and the notional receiving antenna gain including feeder losses. The current section 145 determinations often simplify and groups constants of the propagation model component of MP so that these parameters are not clearly visible in the section 145 determination.

The ACMA proposes that MP actually be expanded to show each of these parameters and assist licensees and other third parties to fully understand the properties and methods of the device boundary criterion. The extent of the proposal is shown in Part 3 of Schedule 2 in Annex A.

## Schedule 3 Effective antenna height

The effective antenna height allows calculation of propagation loss assuming a fixed receiver height relative to the undulating terrain above sea level. Propagation models like Hata use effective antenna heights because they are essentially terrain independent, but focused more on whether transmitters or receivers are high or low sited.

Calculation of the effective antenna height is described graphically in Figure 3 for the current methodology.

|  |
| --- |
| Figure 3 Effective antenna height |
|  |
|  |

The calculation of effective antenna height definition becomes quite difficult to compute when calculating the average ground height of the segment/sector arrangement of Figure 2. This is because there is a requirement to locate DEM cells that are more than half within the area of the segment using difficult computations which could potentially result in some DEM cells being excluded. Because of this, it is believed that a simpler, more robust methodology be developed that removes some of the ambiguities of the current methodology and does not make use of segment/sectors.

This proposed methodology for calculating of average ground height involves only calculating an average of the nearest nine DEM cells to the point on each radial where the device boundary criterion is being calculated. Graphically, this is depicted in Figure 4.

|  |
| --- |
| Figure 4 Proposed average ground height |
| m=500 m  m=1000 m  σn=n.10 |
|  |

This method means that the averaging at each point on each radial is the same, reducing some of the ambiguity that occurs using the segment/sector arrangements of the current section 145 schedules. Full details of the implementation of the average ground height can be found in Part 1 of Schedule 3 in Annex A.

A potential benefit of the proposals in schedule 2 to densify the number of radials and increments at which the device boundary is calculated, is that consideration of the effective antenna height in the first increment is likely to be no longer required as the distance between the transmitter and the first potential device boundary point will be much smaller (i.e. 500 metres).

Schedule 3 also included specific procedures for the calculation of the effective antenna height to be applied to groups of transmitters. Given the proposals in Schedule 1 to remove the towns and roads mobile lists, the number of groups procedures is reduced. Also, a number of proposed changes that are specific to each frequency band may also mean that specific indoor transmitter effective antenna height calculations may also be removed.

An important change that does affect the calculation of the effective antenna height, is the proposed adoption of GDA94 as the datum for spectrum and apparatus licensing. As detailed in the TLG Reference Paper – *GDA94 Adoption*, a simple conversion process from RadDEM in AGD66 to GDA94 is not possible because of a change in the raster points. The ACMA has therefore worked to obtain access to an alternative 9-second DEM that is natively in GDA94 and does not require resampling.

The proposed DEM for adoption is referred to as *GEODATA 9 Second Digital Elevation Model Version 3 (DEM9S)* andis the latest 9-second DEM to be released by Geoscience Australia (with elevation gridding performed by ANU). Full details of the change can be found in the TLG Reference Paper – *GDA94 Adoption*.

# Conclusions

The proposed methodology detailed in this paper aims to improve the accuracy, reliability and ease of implementing the device boundary, and to provide a consistent methodology across all spectrum licences, whether new or approaching expiry.

Each individual Schedule has had significant changes made. A simple run through of the changes is detailed below with full details provided in Annex A:

**Schedule 1**

* Removal of the towns mobile list
* Subsequently, this removes the need for an effective radius of a transmitter

**Schedule 2**

* Change of the increment unit along each radial from minutes to metres
* Increase the number of radials to 360
* As a result of the combination of effective antenna height limits, the propagation model and the frequency band in question, there is an absolute limit in distance from the geographic boundary where a transmitter will always pass the device boundary. This limit is included by limiting the number of increments along each radial that need to be calculated; once the final increment is reached, the transmitter is deemed to pass the device boundary on that radial.
* Remove identification of end points with respect to the spectrum map grid
* Remove aggregation of spectrum map grid cells to form the device boundary
* State that the end points determined along each radial is the device boundary
* Include procedures for a group of transmitters
* Provide a full understanding of how the level of protection and path loss affect the device boundary criterion result by including these parameters explicitly in the formula for calculating the device boundary criterion.
* Include a specific Part for calculation of propagation loss to allow licensees to fully understand what is happening during the calculation of the device boundary.

**Schedule 3**

* Change the heading to include ground height
* Change the mathematical definition of effective antenna height so it is consistent for all increments on the radial
* Include a new Part for the calculation of average ground height (replaces the existing calculation for average ground height known as hagm(φn)).
* Include a new Part for the determination of an end points latitude and longitude along a radial given an initial latitude and longitude (location of the transmitter), an azimuth angle and distance over a spheroid (in this case, GRS80 which is the spheroid of GDA94). This is known as Vincenty’s Formulae and is available in the GDA Technical Manual.
* Remove the requirements for different procedures for the calculation of effective antenna height for an indoor fixed transmitter, group of fixed transmitters or a group of fixed transmitters located near a central point.

# Annex A - Proposed methodology

The following section provides a detailed layout of the proposed Schedules of the section 145 determination on a generic basis. Where sections of the proposed schedule are to contain specific items for a particular band, please refer to the relevant technical liaison group paper.

For example, the 1800 MHz band includes definitions of areas of high mobile use which are not included in the other bands being considered during the technical liaison group process and the 2.5 GHz band is considering maintaining some form of effective radius to account for transmitters in vans with extendable antennas.

The inclusion of Part 2 in Schedule 3 is necessary to enable licensees during the device registration process to determine the latitude and longitude of the mth increment on the nth radial so that the DEM can be queried to obtain the average ground height which is determined in Part 1 of Schedule 3.

Vicenty’s Direct Formulae is provided in the Geocentric Datum of Australia Technical Manual[[1]](#footnote-1) and can be used to find latitude and longitude points over distances of a few centimetres to nearly 20,000 kilometres at various azimuth angles from a given central point, to accuracy within centimetres. It is for this reason it has been proposed as the methodology to determine the latitude and longitude of the mth increment on the nth radial so that the DEM can be queried to obtain the average ground height.

## Schedule 1 Location of a transmitter

1. The location of a transmitter, (l*t*, Lt) is the location (by latitude and longitude with reference to the Geocentric Datum of Australia 1994) of the phase centre of the transmitter’s antenna.
2. For a group of transmitters, (l*t*, Lt) is the location (by latitude and longitude with reference to the Geocentric Datum of Australia 1994) of the centre point between the phase centre of each transmitter antenna within the group.
3. In measuring the location of a transmitter, the measurement error is less than 10 metres

*Note 1: The ACMA issues site identifiers for established radiocommunications locations*

## Schedule 2 Device Boundaries

### Part 1 Device boundary of a transmitter

*Note 1: It is not necessary to calculate the device boundary for transmitters that are exempt from registration – see subsection 69(2) of the Act and the registration conditions of the spectrum licence.*

1. The device boundary of a single transmitter is established as follows:

Step 1: Calculate the device boundary criterion at each m×500 metre increment, where m is the values 1 through ZZ[[2]](#footnote-2), along each of n-degree radials, where n is the values 0 (true north) through 359.

Step 2: For each radial, find the latitude and longitude of the first point (lowest value of *m*) where either:

(a) RP-MP is less than or equal to 0; or

(b) *m* is equal to ZZ

Step 3: The end point for each radial is the device boundary of the transmitter.

1. For a group of transmitters the device boundary to be calculated as if for a single transmitter. The RP for groups of transmitters is taken:

(a) to be equal for each bearing *σn*; and

(b) to have a value that is the maximum horizontally radiated power, in any direction, of any transmitter in the group.

### Part 2 Device boundary criterion

1. The device boundary criterion is the value of the expression:

**

*where:*

|  |  |  |
| --- | --- | --- |
| *MP* | : | *PL(lmn,Lmn) + LOP - Gr* |
| *RP* | : | is the horizontally radiated power, measured in dBm EIRP per 30 kHz, for each bearing, *σn*,measured with an error of ±0.5 dB; |
| *LOP* | : | is the level of protection provided to a nominal receiver height (*hgr)* of PP metres |
| *Gr* | : | is the nominal receiving antenna gain including feeder loss set at (QQ dBi); |
| *PL(lmn, Lnm)* | : | is the propagation loss (dB) set out in Part 3 for the mth increment on the nth radial. |

### Part 3 Calculation of Propagation Loss[[3]](#footnote-3)

1. In calculating *PL(lr, Lr):*

|  |  |  |
| --- | --- | --- |
| *f* | : | assigned frequency of transmitter (megahertz) |
| *hgr* | : | is the nominal receive antenna height above ground level (metres) |
|  | : | is the transmit effective antenna height (metres) as defined in Schedule 3 |
| *d(lmn, Lmn)* | : | is the distance in kilometres between the location of the transmitter, *(lt, Lt)*, and the mth increment on the nth radial *(lmn, Lmn).* |
| *S* | : | is the scaling parameter set to 0 kilometres. |

if  < X metres, then = X metres; or

if  > Y metres then = Y metres.

1. The propagation loss[[4]](#footnote-4) for the mth increment on the nth radial is established as follows:

Step 1: Calculate the constants required

Step 2: Calculate the propagation loss for the mth increment on the nth radial

## Schedule 3 Ground and antenna height

If:

1. *hgt* is the vertical height in metres of the phase centre of the fixed transmitters antenna measured with an error of less than 5 parts in 100 and relative to the point:
   1. located on the line of intersection between the external surface of the structure supporting the antenna and the surface of the ground or sea; and
   2. having the lowest elevation on that line

For a group of transmitters, *hgt* is the greatest of the *hgt* for each individual transmitter in the group, calculated as in (a).

1. *hs* is the sum of the individual DEM9S cell height of the common central point and *hgt*:
2. ** is the average ground height of the DEM9S at each m-increment on each n-radial as calculated in Part 1.

Then the effective antenna height:

1.  is  (as shown in Diagram 1) except when  is less than , in which case  is .

**Diagram 1 Calculating effective antenna height**







hgt



sea level

### Part 1 Average ground height

1. The average ground height for the mth increment on the nth radial is calculated as follows:

Step 1: determine the associated latitude and longitude **of the mth increment on the nth radial as calculated in Part 2.

Step 2: identify the DEM9S cell represented by the latitude and longitude of the mth increment on the nth radial.

Step 3: bound the identified DEM9S cell with the 8 adjacent DEM9S cells in a 3x3 matrix and obtain each DEM9S cell elevation attribute (as shown in Diagram 2).

Step 4: determine the average value of elevation from the 3x3 matrix.

**Diagram 2 Calculating average ground height**

m=500 m

m=1000 m

σn=n.10

### Part 2 Vincenty’s Formulae

*Note 1: This implementation of Vincenty’s Direct Formulae uses the parameters , from the Geocentric Datum of Australian 1994 (GDA 94).*

1. In calculating :

|  |  |  |
| --- | --- | --- |
| l*t* | : | latitude of the fixed transmitter (decimal degrees) |
| Lt | : | longitude of the fixed transmitter (decimal degrees) |
| α | : | azimuth angle (decimal degrees) |
| *d* | : | separation distance to required point (m×500 metres) |
| *a* | : | semi-major axis of GDA94 (6378137m) |
| *fl* | : | flattening of GDA94(1/298.2572221) |
| *b* | : | semi-minor axis of GDA94 (*a×(1-fl)*) |

















1. Using an initial value, iterate the following equations until there is no significant change in .





1. Then,











1. The current version (2.3) is available for download at: <http://www.icsm.gov.au/gda/gdatm/gdav2.3.pdf> [↑](#footnote-ref-1)
2. This maximum number of increments may vary from band to band due to any variance in propagation losses and levels of protection used. [↑](#footnote-ref-2)
3. The effective antenna height () bounds in this Part are subject to consideration by the individual TLG’s for a particular band. [↑](#footnote-ref-3)
4. Details of the specific propagation model used will be defined on a band-by-band basis within TLG groups and included in this part of the s145 Determination. [↑](#footnote-ref-4)