## Perenco post-examination submission

As indicated in the Examination stage, Perenco and the Applicant have engaged in constructive discussions to draft protective provisions that would be acceptable in conjunction with a confidential agreement. Whilst progress has been made, agreement on the protective provisions has yet to be reached.

The key outstanding matter of disagreement is the establishment of cylindrical shaped exclusion corridors in which wind turbine generators shall not be erected to avoid detrimental impact to Perenco's line of sight communication systems. Line of sight communication systems ensure safety critical communication links between Perenco's offshore platforms and its onshore terminals. Disruption to such links would result in an adverse impact on safety and would cause substantial economic losses arising from disruption to Perenco's production operations within and around the Agreement for Lease boundary.

Perenco initially proposed corridors with a two-hundred and fifty (250) metres width. The Applicant did not agree to Perenco's proposal and asked for such corridors to have a fifty (50) metres width subject to (1) obtaining accurate coordinates of line-of-sight transmitter and receiver equipment on all affected platforms, and (2) completion of technical study to demonstrate that fifty (50) metres are sufficient to mitigate potential impacts.

To resolve this disagreement, both parties engaged independent communication systems experts. The Applicant appointed Semco Maritime utilising software developed by ATDI for the calculation of the exclusion zones, while Perenco appointed MMX for such calculations. Due to conflicting results between the two expert assessments, Perenco subsequently commissioned ATDI directly to conduct a refined study using the same software used by Semco to ensure methodological consistency. ATDI's analysis identified fundamental errors in Semco's approach and methodology, with the corrected findings presented in Table 1. The figures stated in Table 1 below represent the recommended minimum diameters of the communication corridors.

*Table 1: Communication Corridors Minimum Distance (Source: adapted from attached ATDI Report)*

| LoS communication link | Minimum Diameter |
|---|---|
| West Sole Alpha to Malory | 360m |
| West Sole Alpha to Lancelot | 180m |
| West Sole Alpha to Excalibur | 170m |
| West Sole Charlie to Malory | 120m |
| Malory to Excalibur | 283m |

Discussions between Perenco and the Applicant are continuing. Perenco therefore asks that the Secretary of State consult with Perenco and the Applicant to ascertain whether a solution has been found such that, if possible, mutually agreed Protective Provisions can be imposed.

MMX's and ATDI's full reports are attached below.

PROPRIETARY

# Coexistence of Microwave Point-to-Point Links and Wind Turbines

# Perenco

## Malory - Windfarm Corridor
## Preliminary Evaluation of Exclusion Zones


Prepared by:

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**Issue Amendment Record:**

**This report has been issued and amended as follows:**

| ISSUE | DESCRIPTION | DATE | AUTHOR-MMX | APPROVAL- PERENCO |
|---|---|---|---|---|
| 00 | First release for review | 27/06/2024 | | |
| 01 | Updated RCS value | 28/03/2025 | | |
| 02 | Updated RCS and C/I values | 28/04/2025 | | |
| 03 | Addition of ATDI study results | 11/07/2025 | | |

# Contents

# 1 Introduction

As one of the potential sources of alternative energy, wind turbines are considered an emerging industry and have been erected in many locations in the UK, as well as around the world. Wind turbines work on the principle of conversion of the kinetic energy from wind into mechanical energy, which is then used to generate electricity. Wind turbines in large numbers are called wind farms and could potentially impact radio communications systems, including broadcasting stations, weather radars, airport radars and terrestrial microwave point-to-point (P2P) systems.
Obstruction, Diffraction, and Reflection/Scattering of radio waves by wind turbines can degrade the performance of a fixed Point-to Point (P2P) radio link because of large blades rotating at approximately 32 rpm. Typically, there are 2 or 3 blades. Thus, any significant interfering signal, such as a delayed multipath component, will fluctuate in signal level around 1.0 to 1.5 Hz.

# 1. The scope

This study is an attempt to propose a practical method for establishing an exclusion zone around the path of fixed radio links within which it would be inadvisable to install a wind turbine. The study will include four fixed P2P links as below

- Malory - West Sole Alpha
- Lancelot - West Sole Alpha
- Excalibur - West Sole Alpha
- West Sole Charlie – Malory
- Malory - Excalibur

Figure 1 shows the path of each MW link passing through Malory windfarm. While Figure 2 shows Malory wind farm perimeter

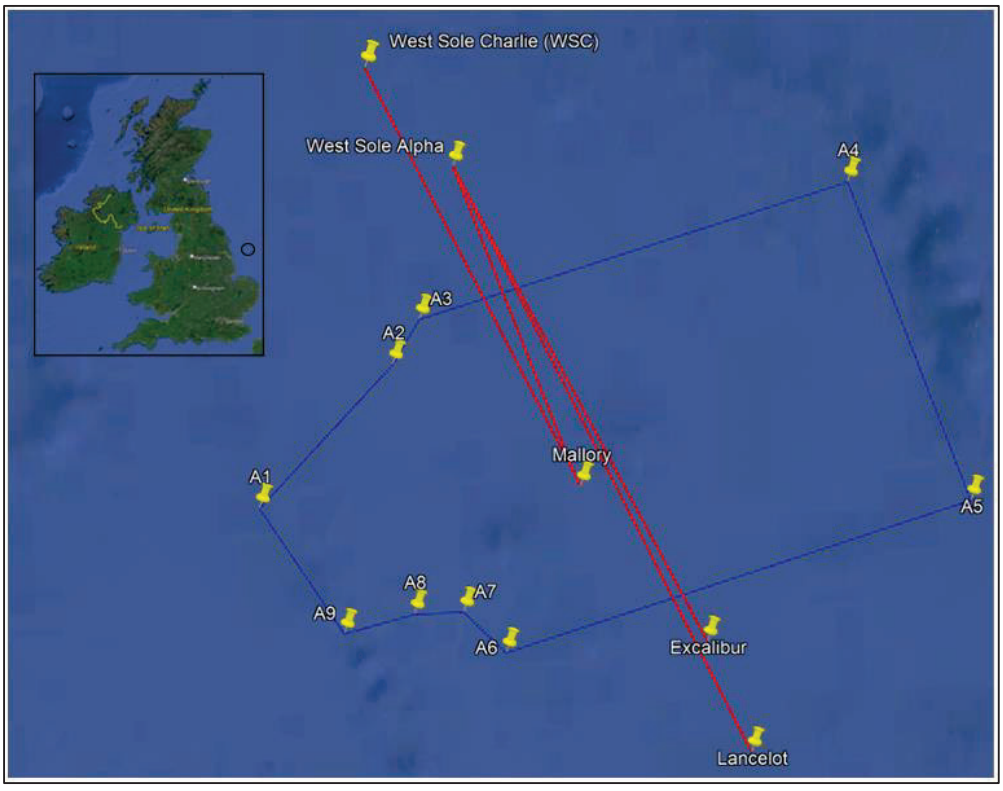



Figure 1. Under study MW links passing through Malory windfarm

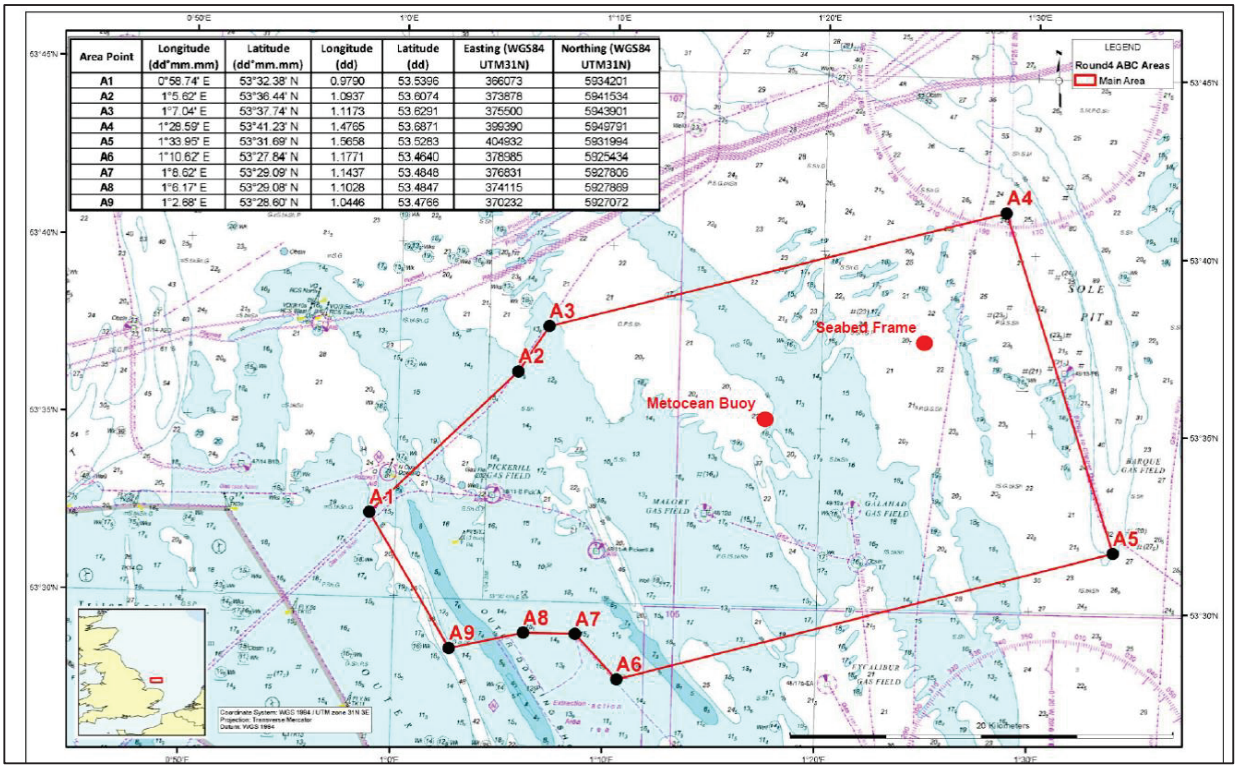



Figure 2. Malory wind farm perimeter

This study identifies three principal degradation mechanisms which are relevant to a wind turbine in proximity to a single radio link. These are;

## 2.1 Near-field effects

The radiation intensity when measured nearer to the antenna, differs from what is away from the antenna. Antenna near-field zones consist of circles drawn round each antenna of radius equal to the nearfield clearance distance as shown in Figure 3.

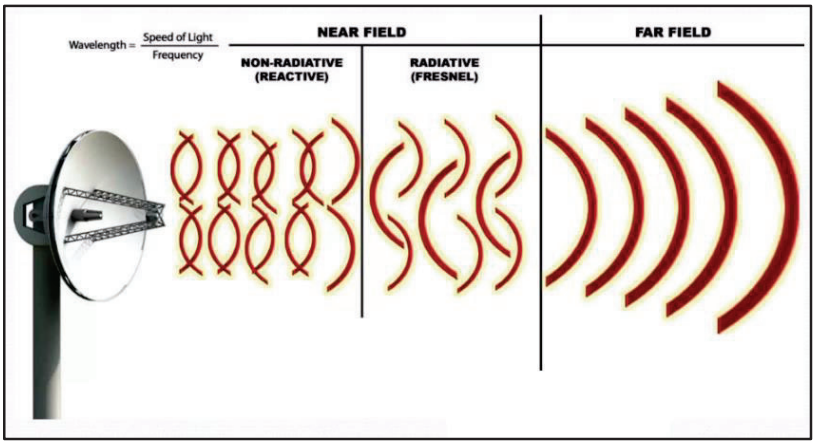



Figure 3. Near-field effects

For a dish or horn type of antenna with an identifiable physical aperture, the nearfield clearance distance ($D_{nf}$ )which can be calculate by

$$D_{\mathrm{nf}} = N_{nf} * \eta * \frac{{D_{\mathrm{a}}}^2}{\lambda} \qquad \ldots (1)$$

where:

$\boldsymbol{N_{nf}}$ : a constant, typically 1 or 2

$\boldsymbol{\eta}$: is the antenna efficiency calculated from the equation below. The efficiency of the antenna (in the range 0.0 to 1.0)

$\boldsymbol{D_a}$ : is the diameter of antenna physical aperture (in meters)

$\boldsymbol{\lambda}$ : is the Wavelength of transmission (in meters)

Antenna efficiency ( $\boldsymbol{\eta}$ ) can be calculated as

$$\eta = \frac{\lambda^2}{(\pi * D_{\mathrm{a}})^2} * 10^{G/10} \qquad \ldots (2)$$

where:

$\boldsymbol{G}$ : is the Antenna Gain in dB (dBi)

$\boldsymbol{\lambda}$ : is the Wavelength of transmission (in meters)

$\boldsymbol{D_a}$ : is the diameter of antenna physical aperture (in meters)

## 2.2 Criterion for Diffraction

Criteria for avoiding diffraction effects are normally based upon an exclusion volume in 3-dimensional space around the (normally line-of-sight (LOS)) radio path of a fixed link.
Such a volume is defined in terms of Fresnel zones as illustrated in Figure 4. The n-th Fresnel is the locus of all points for which, if the radio signal travelled in a straight line from the transmitter to the point and then to the receiver, the additional path length compared to the straight transmitter-receiver path equals nλ/2.

To avoid unwanted diffraction effects, it is recommended that turbines be excluded from an elliptical area equivalent to the area bounded by the 2nd Fresnel Zone ($FZ_{2nd}$) as illustrated below.

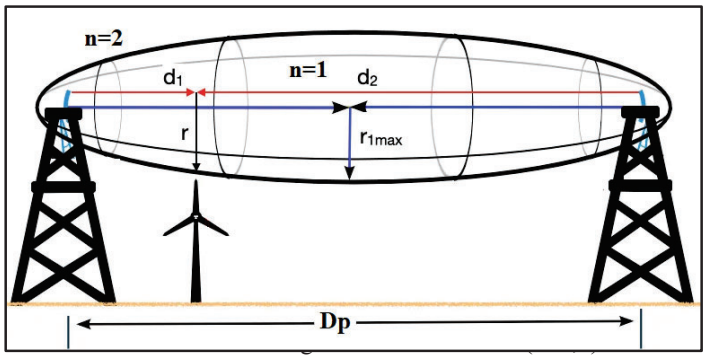



Figure 4. Diffraction exclusion zone

The radius of the 2nd Fresnel Zone ($FZ_{2nd}$) is calculated from the following equation:

$$FZ_{2\mathrm{nd}} = \sqrt{\frac{2*\lambda*d_1*d_2}{(d_1+d_2)}} \qquad \ldots (3)$$

where:

***d1, d2*** : are as illustrated above in Figure 4 (in metres)

$\lambda$ : is the Wavelength of transmission (in meters)

Note that this equation is not quite accurate close to the transmitter and receiver antennas, but near-field and reflection effects dominate at these points so the inaccuracy can reasonably be ignored.

## 2.3 Criterion for Reflection/Scattering

The distinction between "reflection" and "scattering" is only between a coherent (mirror-like) reflection and diffuse scattering. Essentially, they are the same mechanism. When a radio wave illuminates an object, a fraction, possibly a large fraction, of the incident energy is re-radiated in various directions. In pure specular reflection it is wholly re-radiated in the direction of optical reflection, which can only occur from a planar surface. In practice, at radio frequencies many surfaces are either curved or rough in comparison with the wavelength. The re-radiated energy may be somewhat concentrated in a specular direction, but a significant proportion often exists in other directions.
If a radio link transmitter illuminates a wind turbine and some of the reflected or scattered wave enters the receiver, the result is a multipath situation. Unless the level of the reflected/scattered signal is negligible compared to the direct signal, the combination of the signals and the time differences between their modulation may cause performance degradation.

The exclusion zone calculation is based on the concept of Carrier-to-Interference ratio (C/I), usually expressed in dB. A fixed radio link is normally designed to different values of C/I. The choice of C/I ratios will depend on the modulation and coding schemes of the link and the required performance.

The exclusion zone sets a lateral distance from the radio path (*D*s) to ensure that any multipath effects due to reflection or scattering from the wind turbine 'W' are negligible, as shown in Figure 5. Note that all distances are in km and a single wind turbine is considered.

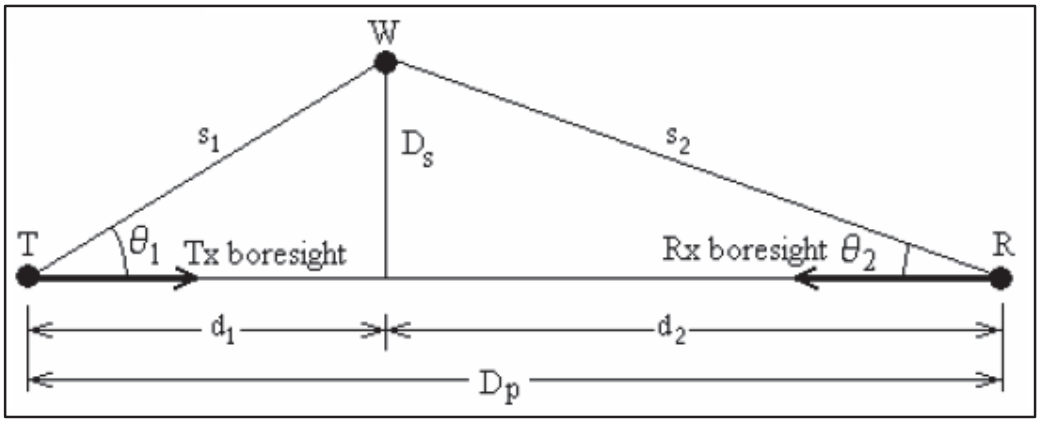



Figure 5. The geometrical model to calculate reflection/scattering exclusion zone

C/I The ratio, expressed in dB, of the wanted signal level received from the direct T-R path divided by the worst-case signal level received from the indirect T-W-R path, is given as:

$$C/I = 71 - S + 20\log_{10}(s_1 * s_2) - 20\log_{10}(Dp) + G_1(0) + G_2(0) - G_1(\Theta 1) - G_2(\Theta 2) \quad \ldots(4)$$

where:

$$S = 10\log_{10}(\sigma) \quad \ldots(5)$$

$$s_{1,2} = \sqrt{{d_{1,2}}^2 + {D_s}^2} \quad \ldots(6)$$

where:

**S :** is a parameter (dB)

**σ :** is the worst-case radar cross section of turbine ($m^2$)

**$G_{1,2}(0)$:** is the boresight gain of the radio antennas (dBi)

**$G_{1,2}(\theta)$ :** is the Antenna gain at off-boresight angles θ (dBi)

For each pair of d1, 2 values, Eq.(4) to Eq.(5) should be used to evaluate C/I for Ds incremented from zero (from a non-zero but small distance in the vicinity of the terminals) upwards in suitably small increments until the required value of C/I ratio, is obtained.

The extent to which an object will reflect, or scatter radio waves is usually quantified by its Radar Cross Section (RCS). This is a property of the complete object and is defined as the area in the plane normal to the direction of illumination which, if it were to re-radiate isotropically all energy incident upon it, would produce the same effective radiated power in a given direction as actually occurs. The RCS of an irregular object is thus a function of the incident and scattered directions in relation to the shape of the object and can vary widely as these directions are changed. It is also important to note that an RCS can be larger than the silhouette of the object as viewed from the direction of illumination.

The exclusion zone calculation should be based on the maximum RCS which can possibly occur, even if this may apply to a given link-turbine layout only rarely.

The initially provide RCS is 74.95dBm$^2$, which is very high and could significantly impact a microwave link. Because the turbines have a very high RCS (74.95dBm$^2$), the links will require a larger clearance to account for the interference effects due to reflections. As the RCS value is a maximum expected figure, a small amount of flexibility has been allowed to show real world effects as detailed below:

Aspect Angle Effects:
- The RCS reported is the maximum RCS — when the turbine is directly facing the radar at its worst angle.
- In practice, because turbines rotate and are seen at oblique angles, the average RCS is lower than the peak.

Rotation and Blade Position:
- Rotating blades cause Doppler shifts and spreading of radar energy, further reducing apparent strength.

Material Properties:
- Some turbine blades use composite materials (fiberglass, carbon fiber) that have lower radar reflectivity compared to metals.
- Radomes (special radar-absorbing coverings) can further reduce RCS.

Clutter Filtering:
- Modern radios have algorithms to filter out moving clutter like turbines.
- This can reduce the operational impact even if the RCS remains large.

Environmental Factors:
- Atmospheric absorption, particularly at higher frequencies), can attenuate reflected signals.

In practice:
- If the maximum RCS is 75 dBm² (and assuming that's real), the operational RCS seen by a microwave link receiver could easily be 10–20 dB lower, especially considering angles, rotation, and distance.
- You could estimate a real-world effective RCS as:

$$\mathrm{RCS}_{\mathrm{effective}} \approx \mathrm{RCS}_{\mathrm{peak}} - (10 \text{ to } 20)\,\mathrm{dB}$$

- Therefore, real world RCS might be around 55–65 dBm² depending on the specifics.
-

This report has been completed with a lower RCS value of 60dBm$^2$ as recommended by Semco Maritime and following the real world affects mentioned above.

Customer to note: If the real-world RCS is greater than 60dBm$^2$, the customers radio performance link will be negatively affected.

# 3. Exclusion Zones

## 3.1 Malory - West Sole Alpha

MW link parameters are listed in below table:

| Link Parameter | |
|---|---|
| Hop Length | 19 Km |
| Frequency | 7.5 GHz |
| Wavelength | 0.04 m |
| Antenna Size | SU2-W71 (0.6m \| 2 ft) |
| Turbine RCS | 60 $dBm^2$ |
| Antenna Gain | 31.3 dBi |

### 3.1.1 Near-Field Clearance

By applying Eq.(1) and Eq.(2) using given Antenna size and Frequency, the near-field distance ($D_{nf}$) is 18m. The near field zone of an antenna will not in general be a sphere. The near-field distance will be different in different directions. For simplicity, and because it is believed that this will not result in impracticable restrictions, it is proposed to take ($D_{nf}$) as given by equation Equ.(1) as the near-field exclusion distances in all directions from the antenna concerned, and to apply this criterion for both terminals of a fixed radio link.
In some literatures [1], it is practicable to plot the antenna near-field clearance (in metres) as a circle around the antenna. However, for readability's sake, as shown in Figure 5, the near-field clearance is presented as a half circle to show the useful information that need to be presented.

### 3.1.2 Diffraction Clearance

By applying Eq.(3) using given the hop length and Frequency, the maximum radius of $FZ_{2nd}$ is: 19.5m. Figure 5 shows diffraction clearance laterally from the radio path as a function of position along the path of the Malory - West Sole Alpha link.

### 3.1.3 Reflection/Scattering Clearance

For the radio link to function with minimal degradation, a minimum value of C/I must be achieved, and for the purposes of this study we have chosen a target C/I ($C/I_T$) of 25dB. Note that this would provide sufficient protection for reflections from 4 turbines located close to the edge of the exclusion zone – calculations would need to be revisited if more turbines are to be located close to the exclusion zone at either end of a path.
Eq. (4) can be used to calculate the worst-case C/I ratio resulting from a given wind turbine at a known position, which typically would be defined by distances $d_1$ and $d_2$, and the side distance $D_s$ in Figure 5. If it is wished to draw an exclusion zone around the link it will, in general, be necessary to iterate [(1)] Eq. (4) for increasing values of $D_s$ until the required value of C/I is obtained, and to do this for different pairs of $d_1$ and $d_2$ values along the path $D_p$.

The calculation using the David Bacon model showed that the worst-case calculated offset distance $D_s$ is 118m at approximately 4.2km from Malory or from West Sole Alpha. It should also be noted that there are large exclusion distances closer to each platform as can be seen below.

| d1 (km) | Ds (m) | C/I (dB) | Target C/I |
|---|---|---|---|
| 0.1 | 45 | 24.74 | 25 |
| 0.5 | 32 | 24.47 | 25 |
| 1 | 54 | 24.24 | 25 |
| 1.5 | 71 | 25.02 | 25 |
| 2 | 87 | 24.96 | 25 |
| 2.5 | 96 | 25.24 | 25 |
| 3 | 105 | 25.26 | 25 |

| | | | |
|---|---|---|---|
| 3.5 | 110 | 24.72 | 25 |
| 4 | 112 | 25.09 | 25 |
| 4.5 | 118 | 25.32 | 25 |
| 5 | 113 | 25.13 | 25 |
| 5.5 | 115 | 25.24 | 25 |
| 6 | 113 | 25.17 | 25 |
| 6.5 | 102 | 24.82 | 25 |
| 7 | 98 | 25.11 | 25 |
| 7.5 | 92 | 25.14 | 25 |
| 8 | 84 | 24.92 | 25 |
| 8.5 | 74 | 25.04 | 25 |
| 9 | 79 | 25.11 | 25 |
| 9.5 | 83 | 24.93 | 25 |
| 10 | 79 | 25.11 | 25 |
| 10.5 | 74 | 25.04 | 25 |
| 11 | 84 | 25.12 | 25 |
| 11.5 | 92 | 25.14 | 25 |
| 12 | 98 | 24.91 | 25 |
| 12.5 | 102 | 24.82 | 25 |
| 13 | 113 | 24.97 | 25 |
| 13.5 | 115 | 24.84 | 25 |
| 14 | 113 | 24.73 | 25 |
| 14.5 | 118 | 24.92 | 25 |
| 15 | 112 | 25.09 | 25 |
| 15.5 | 110 | 24.72 | 25 |
| 16 | 105 | 24.66 | 25 |
| 16.5 | 96 | 24.54 | 25 |
| 17 | 87 | 24.96 | 25 |
| 17.5 | 71 | 25.02 | 25 |
| 18 | 54 | 24.24 | 25 |
| 18.5 | 32 | 24.47 | 25 |
| 18.9 | 45 | 24.74 | 25 |

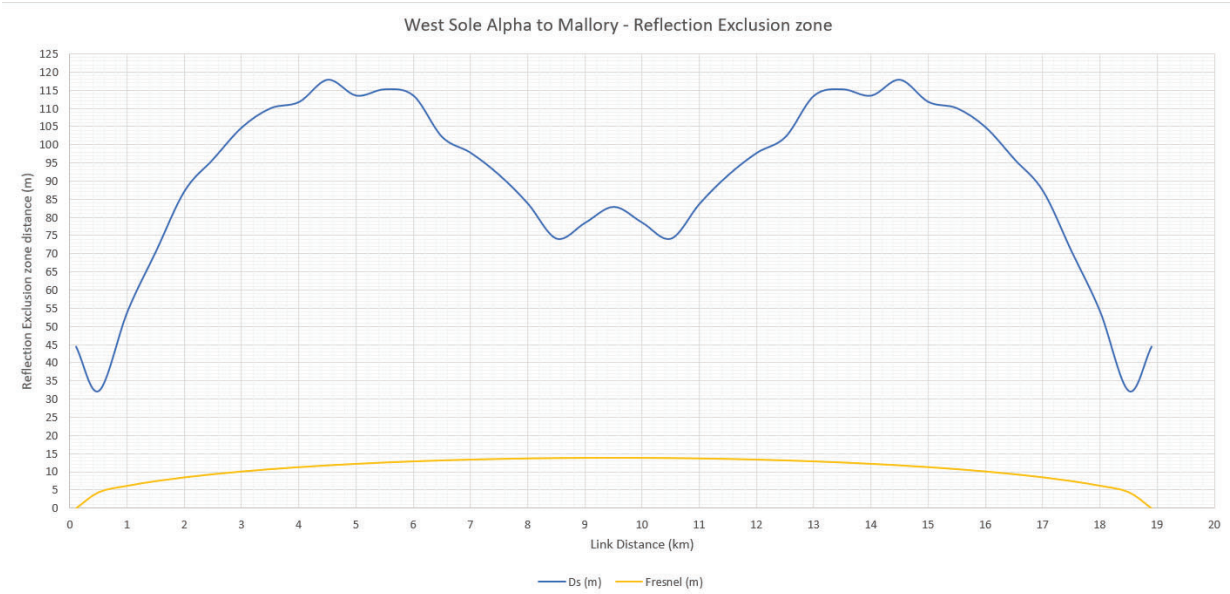



Figure 6. Exclusion zones across the entirety of the Malory to WSA link

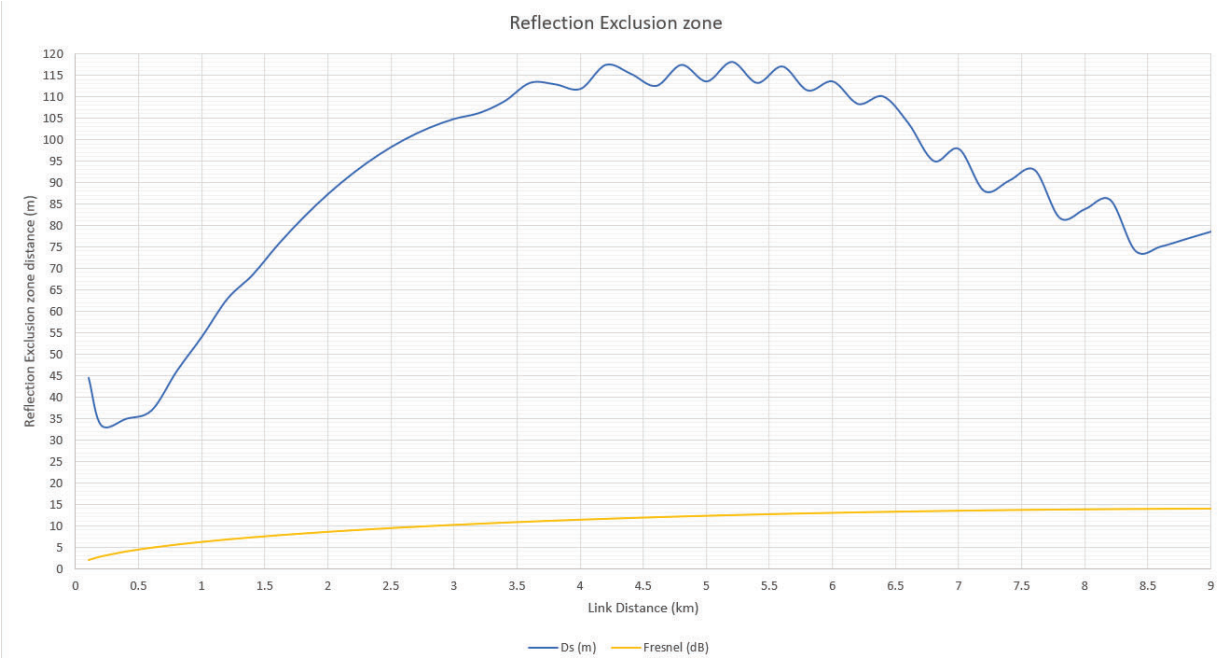



Figure 7. Exclusion zones in the vicinity of each site

### 3.1.4 Malory to WSA Conclusion

The maximum Ds figure seen on the link using the David Bacon model is 118m at 4.5km from each end of the link. Although this is the maximum figure seen, there are different exclusion zone requirements for the complete length of the microwave link. The table and figures above can give a more accurate picture, and any exclusion zones implemented should adhere to the above.

- Reflection/scattering: C/I margin potentially minimum exclusion distance of 236m proposed.

**Third-Party Assessment – [ATDI]**
ATDI validated the 25 dB target C/I threshold using their model and noted that turbines located within 180m laterally ($D_s$) may lead to interference on the link. Based on this, they recommend a minimum lateral exclusion of 360m from the radio path, especially near the terminal sites.

- Reflection/scattering: C/I margin potentially minimum exclusion distance of 360m proposed.
- Overall conclusion: Third-party findings are consistent with internal MMX analysis, with minor conservative adjustments to recommended buffer zones.

*Full third-party report included in Appendix.*

## 3.2 Lancelot - West Sole Alpha

MW link parameters are listed in below table:

| Link Parameter | |
|---|---|
| Hop Length | 36 Km |
| Frequency | 7 GHz |
| Wavelength | 0.04 m |
| Antenna Size | SB4-W71 (1.2m \| 4 ft) |
| Turbine RCS | 60 $dBm^2$ |
| Antenna Gain | 36.9 dBi |

### 3.2.1 Near-Field Clearance

By applying Eq.(1) and Eq.(2) using given Antenna size and Frequency, the Near-field distance ($D_{nf}$) is 18m.

### 3.2.2 Diffraction Clearance

By applying Eq.(3) using given the hop length and Frequency, the maximum radius of $FZ_{2nd}$ is: 19.5m

### 3.2.3 Reflection/Scattering Clearance

The calculation using the David Bacon model showed that the worst-case calculated offset distance $D_s$ is 100m at approximately 3km from Lancelot or from West Sole Alpha.

| d1 (km) | Ds (m) | C/I (dB) | Target C/I |
|---|---|---|---|
| 0.1 | 45 | 24.76 | 25 |
| 1 | 54 | 24.47 | 25 |
| 2 | 84 | 24.63 | 25 |
| 3 | 100 | 25.29 | 25 |
| 4 | 98 | 25.02 | 25 |
| 5 | 87 | 25.18 | 25 |
| 6 | 21 | 24.98 | 25 |
| 7 | 0 | 26.02 | 25 |
| 8 | 0 | 26.88 | 25 |
| 9 | 0 | 27.59 | 25 |
| 10 | 0 | 28.17 | 25 |
| 11 | 0 | 28.66 | 25 |
| 12 | 0 | 29.06 | 25 |
| 13 | 0 | 29.39 | 25 |
| 14 | 0 | 29.64 | 25 |
| 15 | 0 | 29.84 | 25 |
| 16 | 0 | 29.98 | 25 |
| 17 | 0 | 30.06 | 25 |
| 18 | 0 | 30.08 | 25 |
| 19 | 0 | 30.06 | 25 |
| 20 | 0 | 29.98 | 25 |
| 21 | 0 | 29.84 | 25 |
| 22 | 0 | 29.64 | 25 |
| 23 | 0 | 29.39 | 25 |

| | | | |
|---|---|---|---|
| 24 | 0 | 29.06 | 25 |
| 25 | 0 | 28.66 | 25 |
| 26 | 0 | 28.17 | 25 |
| 27 | 0 | 27.59 | 25 |
| 28 | 0 | 26.88 | 25 |
| 29 | 0 | 26.02 | 25 |
| 30 | 21 | 24.98 | 25 |
| 31 | 87 | 25.18 | 25 |
| 32 | 98 | 25.02 | 25 |
| 33 | 100 | 25.29 | 25 |
| 34 | 84 | 25.33 | 25 |
| 35 | 54 | 25.37 | 25 |
| 35.9 | 45 | 24.76 | 25 |

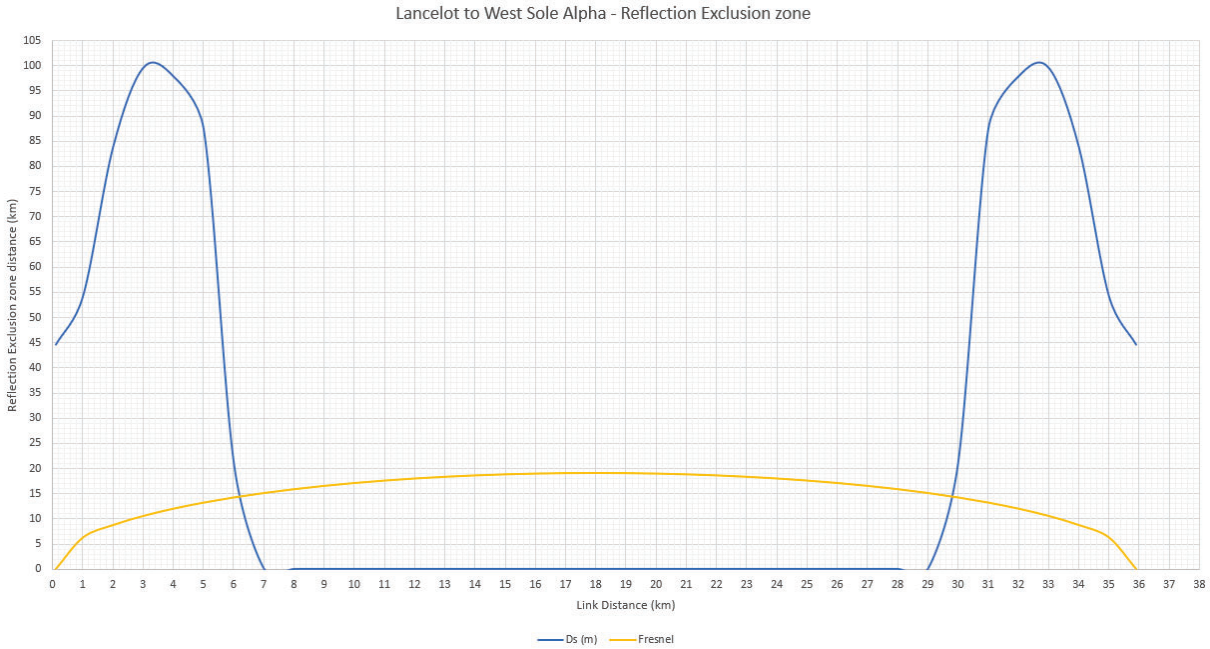



Figure 8. Exclusion zones across the entirety of the Lancelot to WSA link

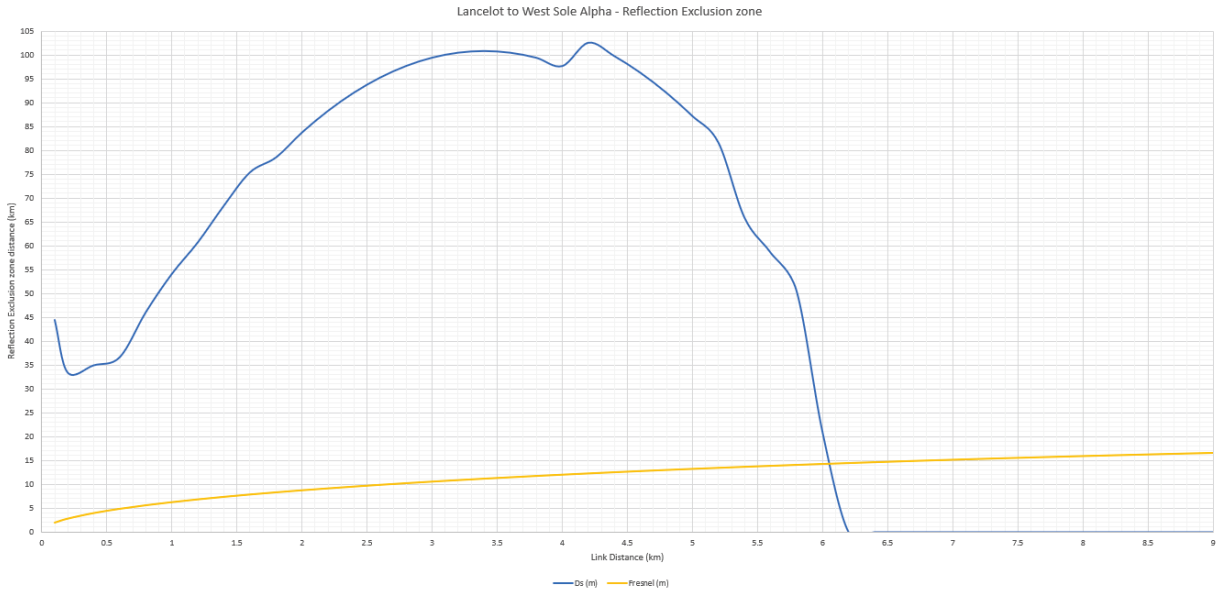



Figure 9. Exclusion zones in the vicinity of each site

### 3.2.4 Lancelot to WSA Conclusion

The maximum Ds figure seen on the link using the David Bacon model is 100m at 3km from each end of the link. Although this is the maximum figure seen, there are different exclusion zone requirements for the complete length of the microwave link. After 7km, the exclusion zone requirements fall below that of the Fresnel zone. At this point, the Fresnel zone exclusion should be used.
The table and figures above can give a more accurate picture, and any exclusion zones implemented should adhere to the above.

- Reflection/scattering: C/I margin potentially minimum exclusion distance of 200m proposed.

**Third-Party Assessment – [ATDI]**
ATDI validated the 25 dB target C/I threshold using their model and noted that turbines located within 90m laterally ($D_s$) may lead to interference on the link. Based on this, they recommend a minimum lateral exclusion of 180m from the radio path, especially near the terminal sites.

- Reflection/scattering: C/I margin potentially minimum exclusion distance of 180m proposed.
- Overall conclusion: Third-party findings are consistent with internal MMX analysis, with minor conservative adjustments to recommended buffer zones.

*Full third-party report included in Appendix.*

## 3.3 Excalibur - West Sole Alpha

MW link parameters are listed in below table:

| Link Parameter | |
|---|---|
| Hop Length | 29.5 Km |
| Frequency | 7 GHz |
| Wavelength | 0.04 m |
| Antenna Size | SB4-W71 (1.2m \| 4 ft) |
| Turbine RCS | 60 $dBm^2$ |
| Antenna Gain | 36.9 dBi |

### 3.3.1 Near-Field Clearance

By applying Eq.(1) and Eq.(2) using given Antenna size and Frequency, the near-field distance ($D_{nf}$) is 72m.

### 3.3.2 Diffraction Clearance

By applying Eq.(3) using given the hop length and Frequency, the maximum radius of the $FZ_{2nd}$ is: 25m

### 3.3.3 Reflection/Scattering Clearance

The calculation using the David Bacon model showed that the worst-case calculated offset distance $D_s$ is 105m at approximately 4.4km from Excalibur or from West Sole Alpha.

| d1 (km) | Ds (m) | C/I (dB) | Target C/I |
|---|---|---|---|
| 0.1 | 45 | 24.76 | 25 |
| 1 | 54 | 25.31 | 25 |
| 2 | 84 | 24.52 | 25 |
| 3 | 100 | 24.62 | 25 |
| 4 | 105 | 24.88 | 25 |
| 5 | 96 | 25.27 | 25 |
| 6 | 63 | 25.19 | 25 |
| 7 | 0 | 25.55 | 25 |
| 8 | 0 | 26.31 | 25 |
| 9 | 0 | 26.92 | 25 |
| 10 | 0 | 27.40 | 25 |
| 11 | 0 | 27.77 | 25 |
| 12 | 0 | 28.05 | 25 |
| 13 | 0 | 28.23 | 25 |
| 14 | 0 | 28.33 | 25 |
| 15 | 0 | 28.35 | 25 |
| 16 | 0 | 28.29 | 25 |
| 17 | 0 | 28.15 | 25 |
| 18 | 0 | 27.92 | 25 |
| 19 | 0 | 27.60 | 25 |
| 20 | 0 | 27.18 | 25 |
| 21 | 0 | 26.64 | 25 |
| 22 | 0 | 25.95 | 25 |
| 23 | 0 | 25.10 | 25 |
| 24 | 77 | 25.02 | 25 |

| | | | |
|---|---|---|---|
| 25 | 102 | 24.93 | 25 |
| 26 | 105 | 24.79 | 25 |
| 27 | 96 | 25.00 | 25 |
| 28 | 71 | 24.38 | 25 |
| 29 | 32 | 24.55 | 25 |
| 29.4 | 45 | 25.76 | 33 |

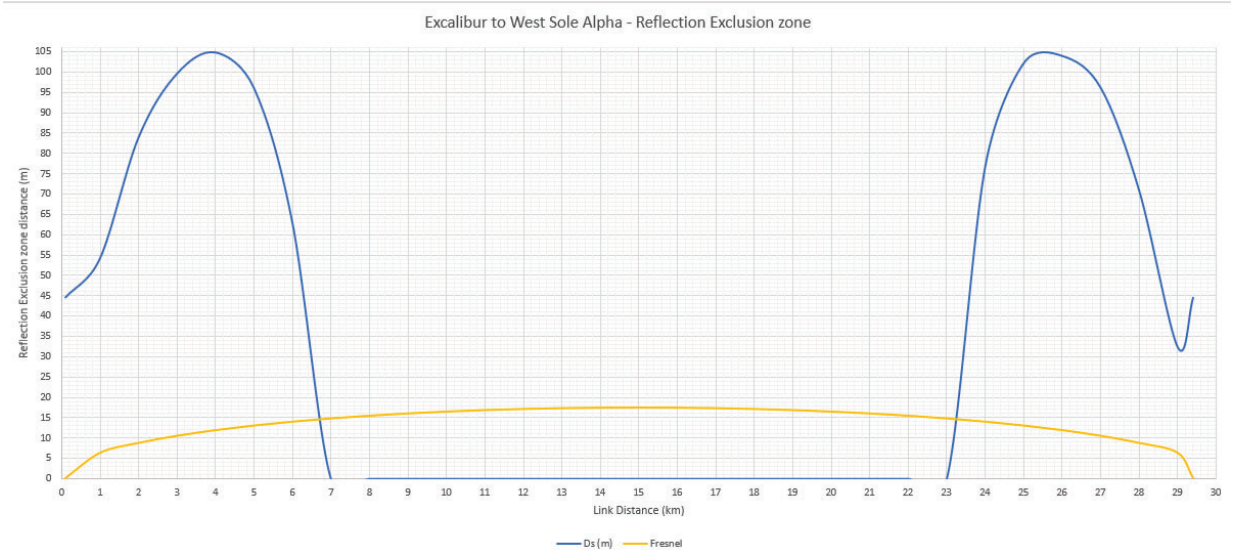



Figure 10. Exclusion zones across the entirety of the Excalibur to WSA link

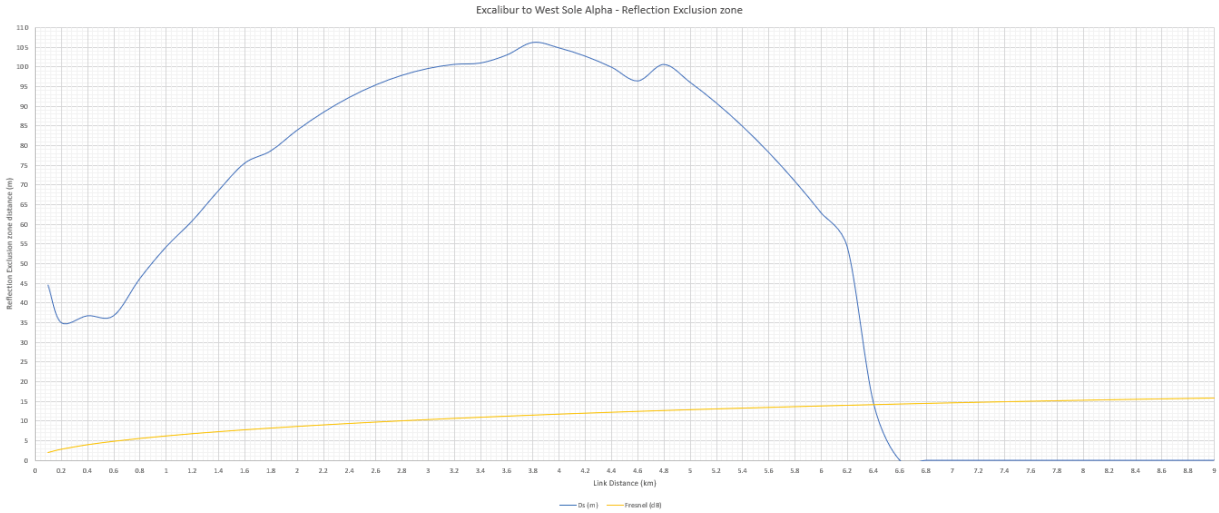



Figure 11. Exclusion zones in the vicinity of each site

### 3.3.4 Excalibur to WSA Conclusion

The maximum Ds figure seen on the link using the David Bacon model is 105m at 4km from each end of the link. Although this is the maximum figure seen, there are different exclusion zone requirements for the complete length of the microwave link. After 7km, the exclusion zone requirements fall below that of the Fresnel zone. At this point, the Fresnel zone exclusion should be used.

The table and figures above can give a more accurate picture, and any exclusion zones implemented should adhere to the above.

- Reflection/scattering: C/I margin potentially minimum exclusion distance of 210m proposed.

**Third-Party Assessment – [ATDI]**
ATDI validated the 25 dB target C/I threshold using their model and noted that turbines located within 85m laterally ($D_s$) may lead to interference on the link. Based on this, they recommend a minimum lateral exclusion of 170m from the radio path, especially near the terminal sites.

- Reflection/scattering: C/I margin potentially minimum exclusion distance of 170m proposed.
- Overall conclusion: Third-party findings are consistent with internal MMX analysis, with minor conservative adjustments to recommended buffer zones.

*Full third-party report included in Appendix.*

## 3.4 West Sole Charlie - Malory

MW link parameters are listed in below table:

| Link Parameter | |
|---|---|
| Hop Length | 25.7 Km |
| Frequency | 13 GHz |
| Wavelength | 0.023 m |
| Antenna Size | UXA4-127B (1.2m \| 4 ft) |
| Turbine RCS | 60 dBm2 |
| Antenna Gain | 41 dBi |

### 3.4.1 Near-Field Clearance

By applying Eq.(1) and Eq.(2) using given Antenna size and Frequency, the near-field distance ($D_{nf}$) is 125m.

### 3.4.2 Diffraction Clearance

By applying Eq.(3) using given the hop length and Frequency, the maximum radius of the $FZ_{2nd}$ is: 17m

### 3.4.3 Reflection/Scattering Clearance

The calculation using the David Bacon model showed that the worst-case calculated offset distance $D_s$ is 105m at approximately 4km from Malory or from West Sole Charlie. It should also be noted that there are also large exclusion distances closer to each platform as can be seen below.

| d1 (km) | Ds (m) | C/I (dB) | Target C/I |
|---|---|---|---|
| 0.1 | 45 | 24.75 | 25 |
| 1 | 54 | 24.37 | 25 |
| 2 | 84 | 24.53 | 25 |
| 3 | 100 | 24.47 | 25 |
| 4 | 105 | 25.08 | 25 |
| 5 | 96 | 25.01 | 25 |
| 6 | 73 | 25.16 | 25 |
| 7 | 0 | 25.15 | 25 |
| 8 | 0 | 25.83 | 25 |
| 9 | 0 | 26.35 | 25 |
| 10 | 0 | 26.73 | 25 |
| 11 | 0 | 26.99 | 25 |
| 12 | 0 | 27.13 | 25 |
| 13 | 0 | 27.17 | 25 |
| 14 | 0 | 27.10 | 25 |
| 15 | 0 | 26.93 | 25 |
| 16 | 0 | 26.64 | 25 |
| 17 | 0 | 26.23 | 25 |
| 18 | 0 | 25.67 | 25 |
| 19 | 24 | 24.94 | 25 |
| 20 | 80 | 25.09 | 25 |
| 21 | 99 | 24.65 | 25 |
| 22 | 104 | 24.60 | 25 |

| | | | |
|---|---|---|---|
| 23 | 100 | 24.98 | 25 |
| 24 | 79 | 25.51 | 25 |
| 25 | 44 | 24.75 | 25 |
| 25.73 | 31 | 28.20 | 25 |

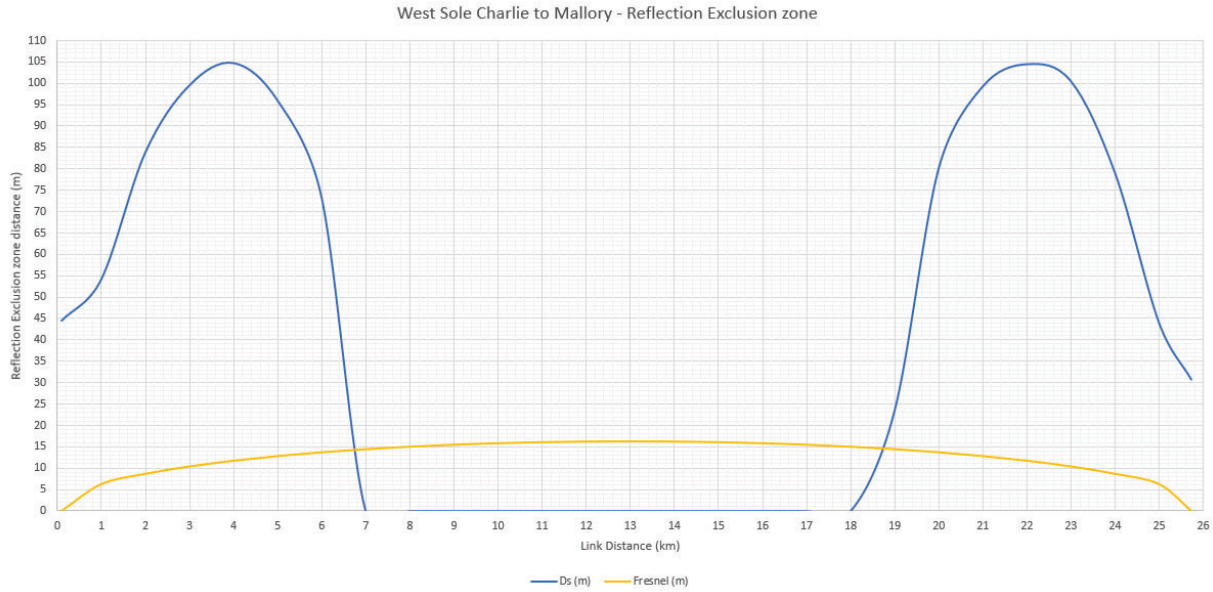



Figure 12. Exclusion zones across the entirety of the WSC to Malory link

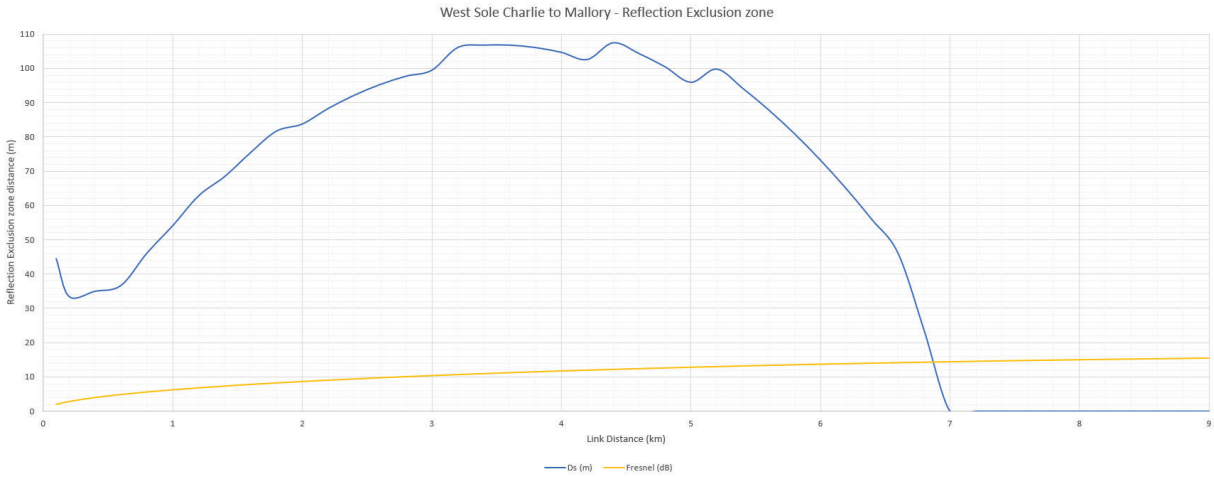



Figure 13. Exclusion zones in the vicinity of each site

### 3.4.4 WSC to Malory Conclusion

The maximum Ds figure seen on the link using the David Bacon model is 105m at 4km from each end of the link. Although this is the maximum figure seen, there are different exclusion zone requirements for the complete length of the microwave link. After 7km, the exclusion zone requirements fall below that of the Fresnel zone. At this point, the Fresnel zone exclusion should be used.

The table and figures above can give a more accurate picture, and any exclusion zones implemented should adhere to the above.

- Reflection/scattering: C/I margin potentially minimum exclusion distance of 210m proposed.

**Third-Party Assessment – [ATDI]**

ATDI validated the 25 dB target C/I threshold using their model and noted that turbines located within 60m laterally ($D_s$)

may lead to interference on the link. Based on this, they recommend a minimum lateral exclusion of 120m from the radio path, especially near the terminal sites.

- Reflection/scattering: C/I margin potentially minimum exclusion distance of 120m proposed.
- Overall conclusion: Third-party findings are consistent with internal MMX analysis, with minor conservative adjustments to recommended buffer zones.

*Full third-party report included in Appendix.*

## 3.5 Malory - Excalibur

MW link parameters are listed in below table:

| Link Parameter | |
|---|---|
| Hop Length | 11 Km |
| Frequency | 13 GHz |
| Wavelength | 0.023 m |
| Antenna Size | UXA4-127B (1.2m \| 4 ft) |
| Turbine RCS | 60 $dBm^2$ |
| Antenna Gain | 36 dBi |

### 3.5.1 Near-Field Clearance

By applying Eq.(1) and Eq.(2) using given Antenna size and Frequency, the near-field distance ($D_{nf}$) is 125m. The near field zone of an antenna will not in general be a sphere. The near-field distance will be different in different directions. For simplicity, and because it is believed that this will not result in impracticable restrictions, it is proposed to take ($D_{nf}$) as given by equation Equ.(1) as the near-field exclusion distances in all directions from the antenna concerned, and to apply this criterion for both terminals of a fixed radio link.

In some literatures [1], it is practicable to plot the antenna near-field clearance (in metres) as a circle around the antenna. However, for readability's sake, as shown in Figure 5, the near-field clearance is presented as a half circle to show the useful information that need to be presented.

### 3.5.2 Diffraction Clearance

By applying Eq.(3) using given the hop length and Frequency, the maximum radius of $FZ_{2nd}$ is: 12m. Figure 5 shows diffraction clearance laterally from the radio path as a function of position along the path of the Malory - West Sole Alpha link.

### 3.5.3 Reflection/Scattering Clearance

The calculation using the David Bacon model showed that the worst-case calculated offset distance $D_s$ is 131m at approximately 5km from Malory or from Excalibur. It should also be noted that there are large exclusion distances closer to each platform as can be seen below.

| d1 (km) | Ds (m) | C/I (dB) | Target C/I |
|---|---|---|---|
| 0.1 | 45 | 25.81 | 25 |
| 0.5 | 32 | 25.40 | 25 |
| 1 | 56 | 24.89 | 25 |
| 1.5 | 73 | 25.37 | 25 |
| 2 | 87 | 24.50 | 25 |
| 2.5 | 100 | 25.45 | 25 |
| 3 | 110 | 24.71 | 25 |
| 3.5 | 116 | 25.10 | 25 |
| 4 | 124 | 24.77 | 25 |
| 4.5 | 127 | 24.95 | 25 |
| 5 | 131 | 25.38 | 25 |
| 5.5 | 127 | 24.67 | 25 |
| 6 | 126 | 24.61 | 25 |
| 6.5 | 128 | 25.31 | 25 |
| 7 | 122 | 24.86 | 25 |
| 7.5 | 119 | 25.43 | 25 |
| 8 | 112 | 24.89 | 25 |

| | | | |
|---|---|---|---|
| 8.5 | 104 | 25.19 | 25 |
| 9 | 92 | 24.83 | 25 |
| 9.5 | 75 | 24.24 | 25 |
| 10 | 60 | 25.63 | 25 |
| 10.5 | 38 | 25.90 | 25 |
| 11 | 45 | 25.81 | 25 |

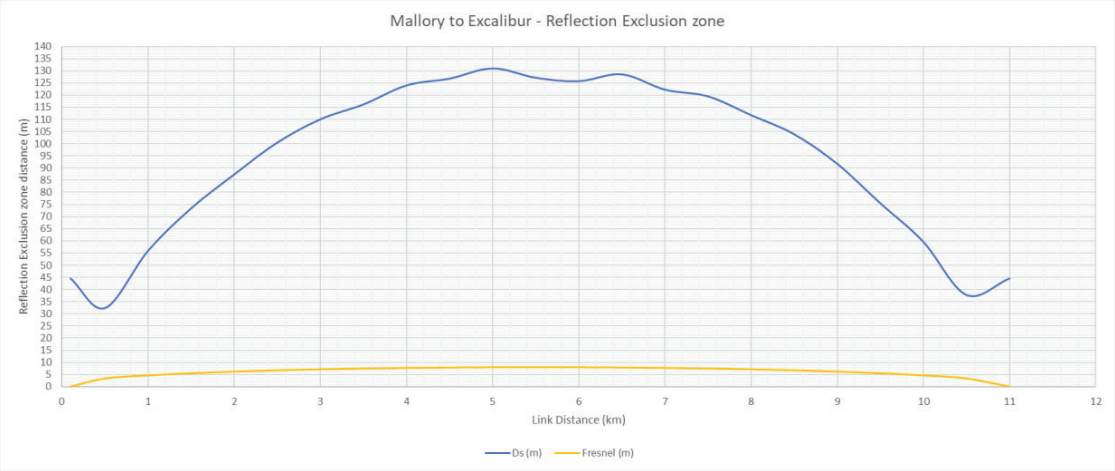



Figure 6. Exclusion zones across the entirety of the Malory to Excalibur link

### 3.5.4 Malory to Excalibur Conclusion

The maximum Ds figure seen on the link using the David Bacon model is 131m at 5km from each end of the link. Although this is the maximum figure seen, there are different exclusion zone requirements for the complete length of the microwave link. The table and figures above can give a more accurate picture, and any exclusion zones implemented should adhere to the above.

- Reflection/scattering: C/I margin potentially minimum exclusion distance of 262m proposed.

**Third-Party Assessment – [ATDI]**

ATDI validated the 25 dB target C/I threshold using their model and noted that turbines located within 141.5m laterally ($D_s$) may lead to interference on the link. Based on this, they recommend a minimum lateral exclusion of 283m from the radio path, especially near the terminal sites.

- Reflection/scattering: C/I margin potentially minimum exclusion distance of 283m proposed.
- Overall conclusion: Third-party findings are consistent with internal MMX analysis, with minor conservative adjustments to recommended buffer zones.

*Full third-party report included in Appendix.*

# 4. Explanation of Modelling Differences

Slight differences have been observed between the in-house analysis (using the David Bacon model) and the third-party results (generated using ATDI HTZ software). These discrepancies are expected and are due to inherent differences in modelling approach, assumptions, and resolution.

| Model | David Bacon Model | ATDI HTZ Warfare |
|---|---|---|
| Type | Analytical, semi-empirical | Full 3D geospatial simulation (raytracing / ITU-R based) |
| Purpose | Designed specifically for microwave exclusion zone assessment | Multi-band RF planning & terrain-aware interference analysis |
| Geometry | Idealized paths with limited terrain data | Terrain-following, environment-specific modelling |
| Turbine Modelling | Simplified RCS assumptions (static value) | RCS modelled dynamically based on blade orientation, geometry, and range |

## 4.1 Resolution and Assumptions

- **Terrain and Clutter:**
  The ATDI model uses high-resolution terrain elevation and clutter databases (e.g., 1–5 m resolution), which can slightly extend exclusion zones based on local landforms (e.g., rig structure, platform elevation). The David Bacon model typically uses averaged parameters or assumes flat-earth conditions.

- **Reflection and Multipath Treatment:**
  ATDI HTZ includes 3D ray-tracing and specular reflection analysis, which may predict reflection-induced C/I degradation at different distances than the simpler fixed-geometry assumptions in the Bacon model.

- **Environmental Margins:**
  The third-party model may apply conservative buffer values or worst-case turbine placement within a simulation grid, increasing exclusion distances marginally.

## 4.2 Which Results Should Be Relied On?

Both models are technically valid and appropriate for engineering analysis, but the choice of which to rely on depends on the intended use and risk tolerance:

- **David Bacon Model**
  - **Strengths:** Simple, well-understood, quick for feasibility studies.
  - **Limitations:** Less suitable for complex topographies or dense wind farm layouts.
  - **Best for:** Early-phase risk screening or uniform siting constraints.

- **ATDI HTZ Model**
  - **Strengths:** High-fidelity, location-specific modelling with terrain and structure integration.
  - **Limitations:** Requires calibration, assumes availability of accurate terrain/clutter/RCS data.
  - **Best for:** Final siting decisions, detailed licensing submissions, or compliance evidence.

## 4.3 Recommendation

Given the context of a critical infrastructure link and potential operational impact, it is prudent to adopt a conservative position:
Use the ATDI HTZ results as the primary basis for exclusion zone setting, while retaining the Bacon model results as a secondary verification layer for consistency and transparency.
This dual-modelling approach demonstrates due diligence and provides technical defensibility in regulatory or safety-critical contexts.

# 5. References

[1] D F Bacon, *A proposed method for establishing an exclusion zone around a terrestrial fixed radio link outside of which a wind turbine will cause negligible degradation of the radio link performance*, Version 1.1, 28th October 2002

[2] [Online-Accessed 27/06/2024]

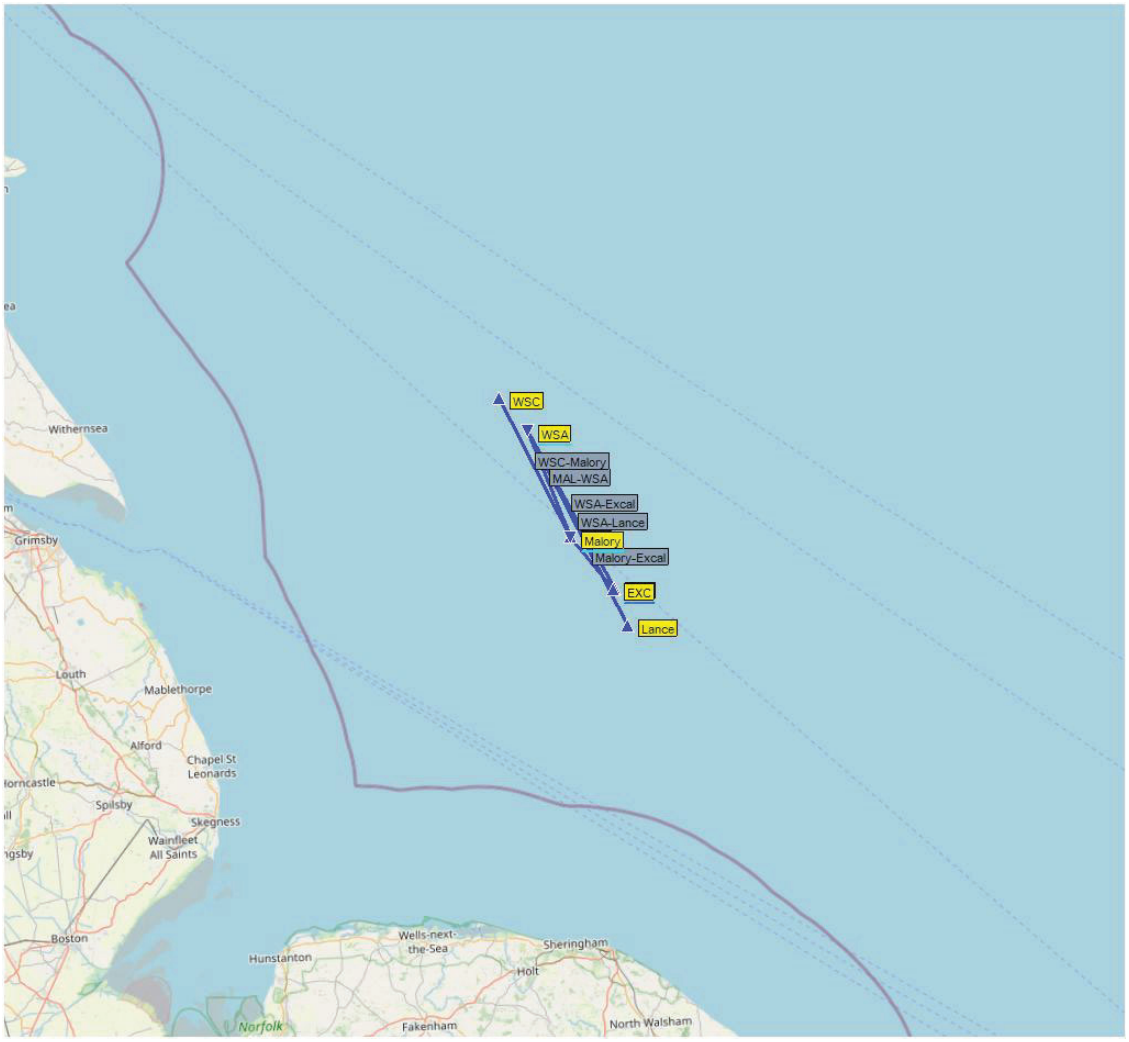
[3] ATDI Exclusion zone report - WT Exclusion areas V3.0

# 6. Appendix

ATDI Exclusion zone report - WT Exclusion areas V3.0

# WT Exclusion areas

# V3.0



# Table of Contents

# 1. Introduction

The purpose of this study is to create exclusion areas of Wind Turbines around five MW links located on off-shore platforms.

Exclusion areas will be built for each MW link considered in turn.
The combination of all exclusion areas built for each MW link has also been performed, considering the worst case (maximum interference level) found on each point.

# 2. MW links and WT

The location and parameters of the different MW links have been provided by MMX and are coming from OFCOM UK (technical specifications associated with each license).

The parameters of the virtual WT (Mast height, Blade size and RCS) have been agreed with MMX.

## 2.1. MW links location and parameters

The location and parameters of each MW link are listed in the below tables.

**POINT TO POINT FIXED LINKS**

**SCHEDULE 2 TO LICENCE NUMBER 1127076/1**

**TECHNICAL SPECIFICATION**

| | | | | | |
|---|---|---|---|---|---|
| **Licence No** | 1127076/1 | **Start Date** | 16/08/2017 | **Renewal Date** | 28/02/2018 |
| **Licensee Name** | PERENCO UK LIMITED | | | | |
| **Licensee Reference No** | 1-LQU-106 | | | | |
| **Customer Link Id** | WSA-Excal | | | | |
| **Technical Schedule** | | | | | |
| Band (GHz) | 7.5 GHz | | | | |
| Channel Spacing (MHz) | 7 | | | | |
| Channel Number | 4 | | | | |
| Equipment Reference Code | E/75/EZ/17/098/NE | | | | |
| Bit Rate (Mbit/s) | 16 | | | | |
| Modulation | D7 | | | | |
| Propagation Availability (%) | 99.995 | | | | |
| Polarisation | V - Vertical linear | | | | |
| Path Length (km) | 29.50 | | | | |
| **Station** | **A** | | | **B** | |
| Location of Station | TB 22132 01683 | | | TB 08000 27596 | |
| Station Name | ~~WSA~~ EXC | | | WSA | |
| Transmit Frequencies (GHz) | 7.4525 | | | 7.6975 | |
| Equivalent Isotropically Radiated Power (dBW) in the direction of maximum radiation. | 22 | | | 22.5 | |
| Antenna Reference Code | A/75/H/15/024/RF | | | A/75/H/15/024/RF | |
| Antenna Gain (dBi) | 37 | | | 37 | |
| Antenna Azimuth (degrees) | 334.14 | | | 153.98 | |
| Antenna Height (m) | 30.00 | | | 30.00 | |
| Antenna Elevation (degrees) | -0.10 | | | -0.10 | |
| Feeder Losses (dB) | 0.0 | | | 0.0 | |
| Other Losses (dB) | 0.0 | | | 0.0 | |
| Fade Margin (dB) | 29.35 | | | 29.16 | |

**POINT TO POINT FIXED LINKS**

**SCHEDULE 2 TO LICENCE NUMBER 1129526/2**

**TECHNICAL SPECIFICATION**

| **Licence No** 1129526/2 | **Start Date** 01/09/2017 | **Renewal Date** 28/02/2018 |
|---|---|---|
| **Licensee Name** | PERENCO UK LIMITED | |
| **Licensee Reference No** | 1-LQU-106 | |
| **Customer Link Id** | WSA-Lance | |
| **Technical Schedule** | | |
| Band (GHz) | 7.5 GHz | |
| Channel Spacing (MHz) | 7 | |
| Channel Number | 1 | |
| Equipment Reference Code | E/75/EZ/17/098/NE | |
| Bit Rate (Mbit/s) | 16 | |
| Modulation | D7 | |
| Propagation Availability (%) | 99.995 | |
| Polarisation | V - Vertical linear | |
| Path Length (km) | 36.00 | |
| **Station** | **A** | **B** |
| Location of Station | TG 24431 95661 | TB 08000 27596 |
| Station Name | Lancelot Platform,North Sea | WSA Platform,North Sea |
| Transmit Frequencies (GHz) | 7.4315 | 7.6765 |
| Equivalent Isotropically Radiated Power (dBW) in the direction of maximum radiation. | 31.4 | 31.9 |
| Antenna Reference Code | A/75/H/15/024/RF | A/75/H/15/024/RF |
| Antenna Gain (dBi) | 37 | 37 |
| Antenna Azimuth (degrees) | 335.54 | 155.36 |
| Antenna Height (m) | 30.00 | 37.00 |
| Antenna Elevation (degrees) | -0.11 | -0.13 |
| Feeder Losses (dB) | 4.0 | 4.0 |
| Other Losses (dB) | 2.0 | 2.0 |
| Fade Margin (dB) | 31.01 | 30.87 |

**POINT TO POINT FIXED LINKS**

**SCHEDULE 2 TO LICENCE NUMBER 1204275/1**

**TECHNICAL SPECIFICATION**

| **Licence No** 1204275/1 | **Start Date** 17/09/2019 | **Renewal Date** 29/02/2020 |
|---|---|---|
| **Licensee Name** | PERENCO UK LIMITED | |
| **Licensee Reference No** | 1-LQU-106 | |
| **Customer Link Id** | MAL-WSA | |
| **Technical Schedule** | | |
| Band (GHz) | 7.5 GHz | |
| Channel Soacina (MHz) | 14 | |
| Channel Number | 7 | |
| Eauioment Reference Code | E/75/WS/17/133/NE | |
| Bit Rate (Mbit/s) | 32 | |
| Modulation | D7 | |
| Prooaaation Availability (%) | 99.995 | |
| Polarisation | V - Vertical linear | |
| Path Lenath (km) | 19.00 | |
| **Station** | **A** | **B** |
| Location of Station | TB 15048 10146 | TB 08019 27597 |
| Station Name | Mallory,Southern North Sea | West Sole Alpha,Southern North Sea |
| Transmit Freauencies (GHz) | 7.519 | 7.764 |
| Equivalent Isotropically Radiated Power (dBW) in the direction of maximum radiation. | 34.5 | 21.4 |
| Antenna Reference Code | A/75/H/07/015/RF | /75/H/07/015/RF |
| Antenna Gain (dBi) | 31 | 31 |
| Antenna Azimuth (dearees) | 340.72 | 160.64 |
| Antenna Heiaht (m) | 25.00 | 30.00 |
| Antenna Elevation (dearees) | -0.05 | -0.08 |
| Feederlosses<dB) | 1.5 | 15.0 |
| Other Losses (dB) | 1.0 | 1.0 |
| Fade MarQin (dB) | 21.17 | 20.99 |

**POINT TO POINT FIXED LINKS**

**SCHEDULE 2 TO LICENCE NUMBER 1294588/1**

**TECHNICAL SPECIFICATION**

| **Licence No** 1294588/1 | **Start Date** 20/10/2022 | **Renewal Date** 28/02/2023 |
|---|---|---|
| **Licensee Name** | PERENCO UK LIMITED | |
| **Licensee Reference No** | 1-LQU-106 | |
| **Customer Link Id** | WSC-Malory | |
| **Technical Schedule** | | |
| Band (GHz) | 13 GHz | |
| Channel Spacing (MHz) | 28 | |
| Channel Number | 1 | |
| Equipment Reference Code | E/13/EF/07/023/NE | |
| Bit Rate (Mbit/s) | 100 | |
| Modulation | G7 | |
| Propagation Availability (%) | 99.990 | |
| Polarisation | V - Vertical linear | |
| Path Length (km) | 25.70 | |
| **Station** | **A** | **B** |
| Location of Station | TB 03230 32989 | TB 15043 10115 |
| Station Name | West Sole Charlie,Southern North Sea | Malory,Southern North Sea |
| Transmit Frequencies (GHz) | 12.765 | 13.031 |
| Equivalent Isotropically Radiated Power (dBW) in the direction of maximum radiation. | 31.9 | 32.1 |
| Antenna Reference Code | A/13/H/16/012/RF | A/13/H/16/012/RF |
| Antenna Gain (dBi) | 41 | 41 |
| Antenna Azimuth (degrees) | 155.22 | 335.35 |
| Antenna Height (m) | 30.00 | 27.00 |
| Antenna Elevation (degrees) | -0.09 | -0.08 |
| Feeder Losses (dB) | 3.0 | 3.0 |
| Other Losses (dB) | 2.0 | 2.0 |
| Fade Margin (dB) | 25.86 | 25.85 |

**POINT TO POINT FIXED LINKS**

**SCHEDULE 2 TO LICENCE NUMBER 0426979/2**

**TECHNICAL SPECIFICATION**

| **Licence No** 0426979/2 | **Start Date** 30/07/2007 | **Renewal Date** 29/02/2020 |
|---|---|---|
| **Licensee Name** | PERENCO UK LIMITED | |
| **Licensee Reference No** | 1-LQU-106 | |
| **Customer Link Id** | 26979 | |
| **Technical Schedule** | | |
| Band (GHz) | 13 GHz | |
| Channel Spacing (MHz) | 14 | |
| Channel Number | 2 | |
| Equipment Reference Code | E/13/WS/17/173/NE | |
| Bit Rate (Mbit/s) | 32 | |
| Modulation | D7 | |
| Propagation Availability (%) | 99.990 | |
| Polarisation | V - Vertical linear | |
| Path Length (km) | 11.10 | |
| **Station** | **A** | **B** |
| Location of Station | TB 14900 10100 | TB 22000 01600 |
| Station Name | MALLORY PLATFORM NORTH SEA | MOBIL EXCALIBUR PLATFORM |
| Transmit Frequencies (GHz) | 13.038 | 12.772 |
| Equivalent Isotropically Radiated Power (dBW) in the direction of maximum radiation. | 12.5 | 12.3 |
| Antenna Reference Code | A/13/O/83/007/AA | A/13/O/83/007/AA |
| Antenna Gain (dBi) | 35 | 35 |
| Antenna Azimuth (degrees) | 142.80 | 322.88 |
| Antenna Height (m) | 35.00 | 35.00 |
| Antenna Elevation (degrees) | -0.04 | -0.04 |
| Feeder Losses (dB) | 3.5 | 3.5 |
| Other Losses (dB) | 0.0 | 0.0 |
| Fade Margin (dB) | 15.00 | 15.00 |

## 2.2. WT parameters

A virtual WT has been considered located the MW links with the following characteristics :

- Mast height: 100m
- Blade radius : 61m
- RCS: 60dBsm

## 3. Cartographic database

The different cartographic layers used in this study were produced by ATDI at a resolution of 200m and are made of:

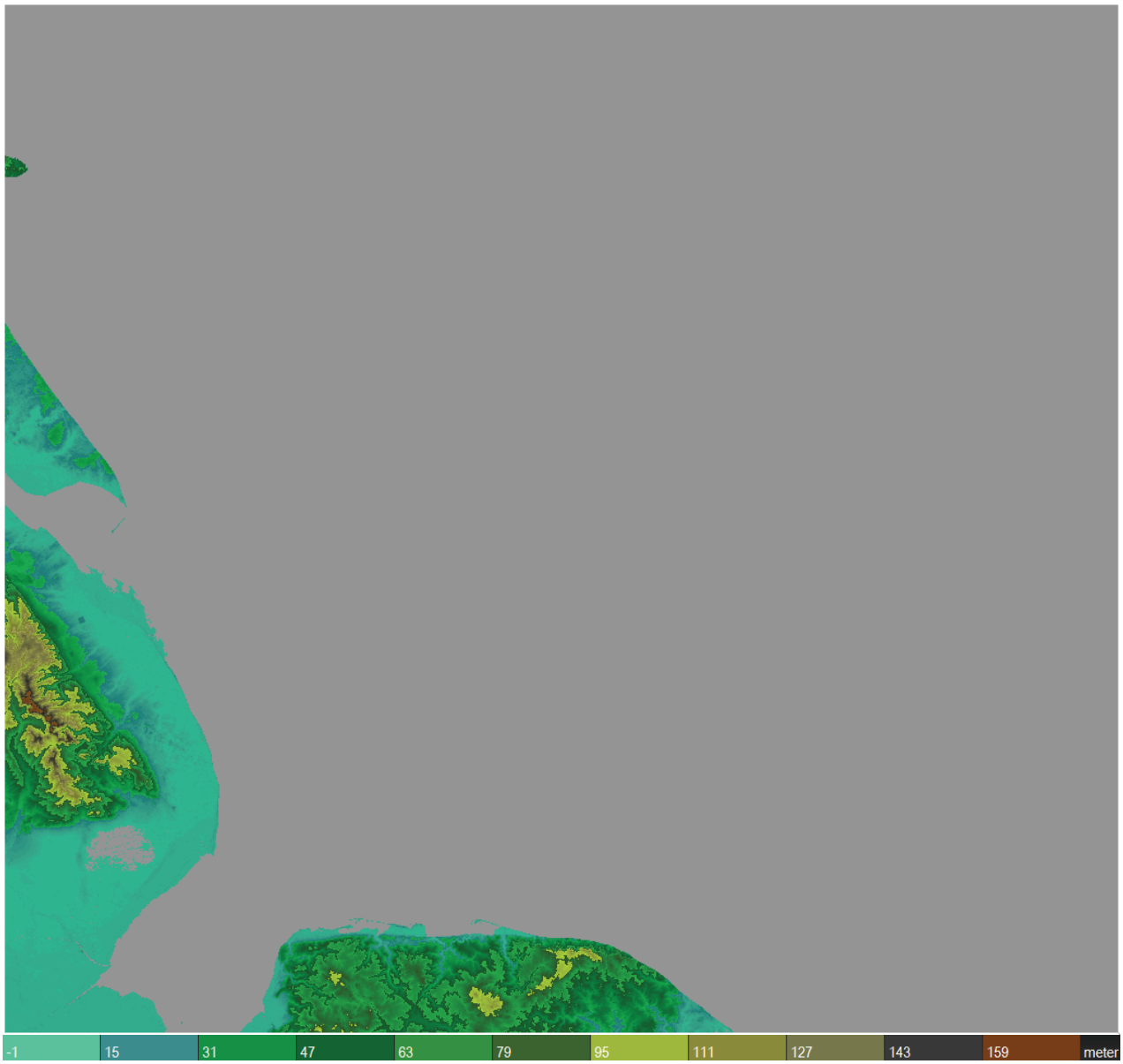
- A Digital Terrain Model (DTM) describing the altitude of the ground.

- A Clutter layer describing the type of land use at each point with the following classification:
  Code 0: Rural area - 0m above the ground.
  Code 5: Forest - 10m above the ground.
  Code 6: Hydrology - 0m / 5m above the round.
  Code 8: Park/Wood - 4m above the ground.
  Code 9: Building - Building height above the ground.
  Code 10: Rail - 0m above the ground.
  Code 11: Road - 0m above the ground.
  Code 12: Airport - 0m above the ground.
  Code 14: Open rural – 2m above the ground.

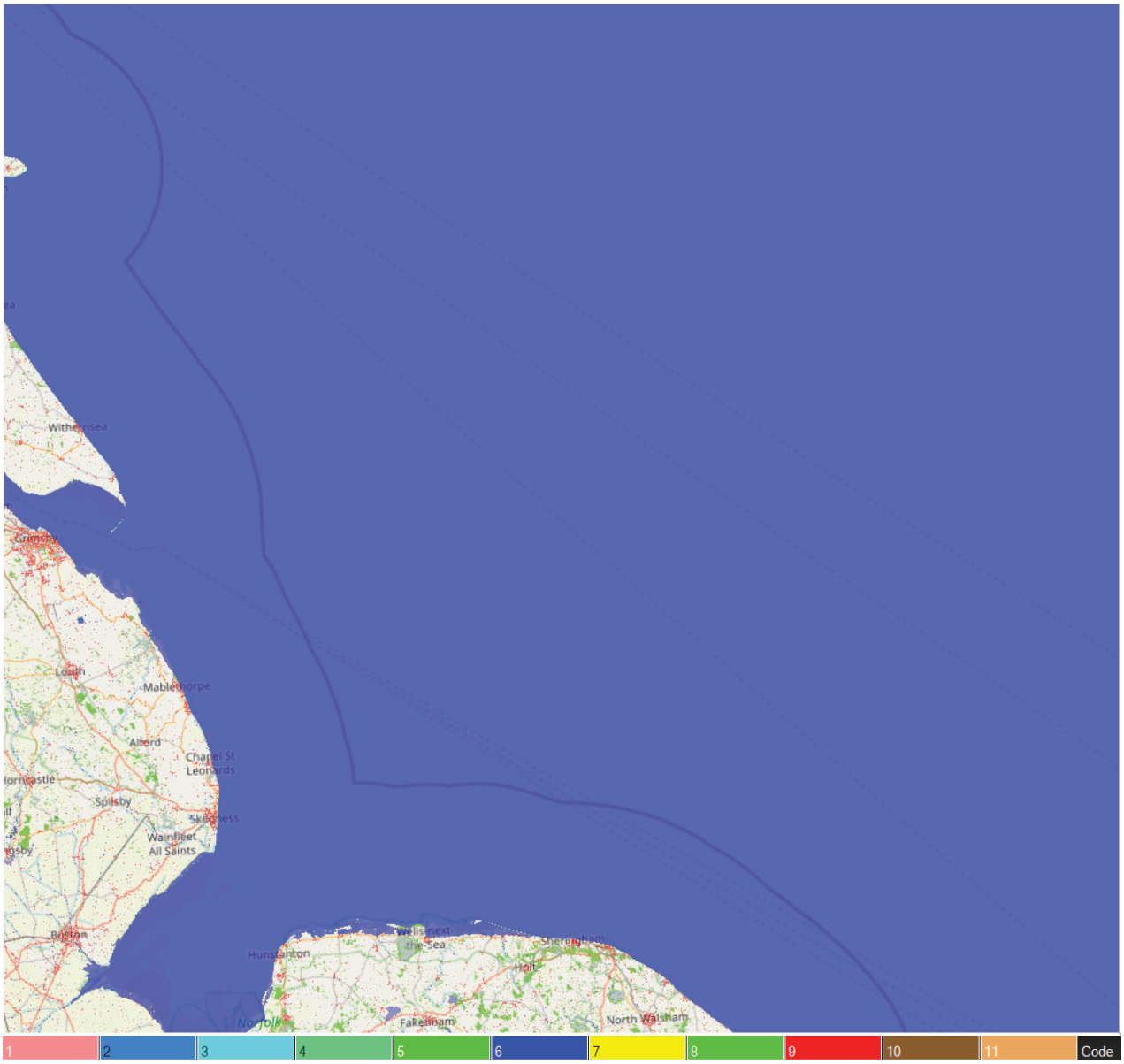
- A building layer describing the shape and the height of each building above ground level.

- A background image provided by Bing(tm) servers.

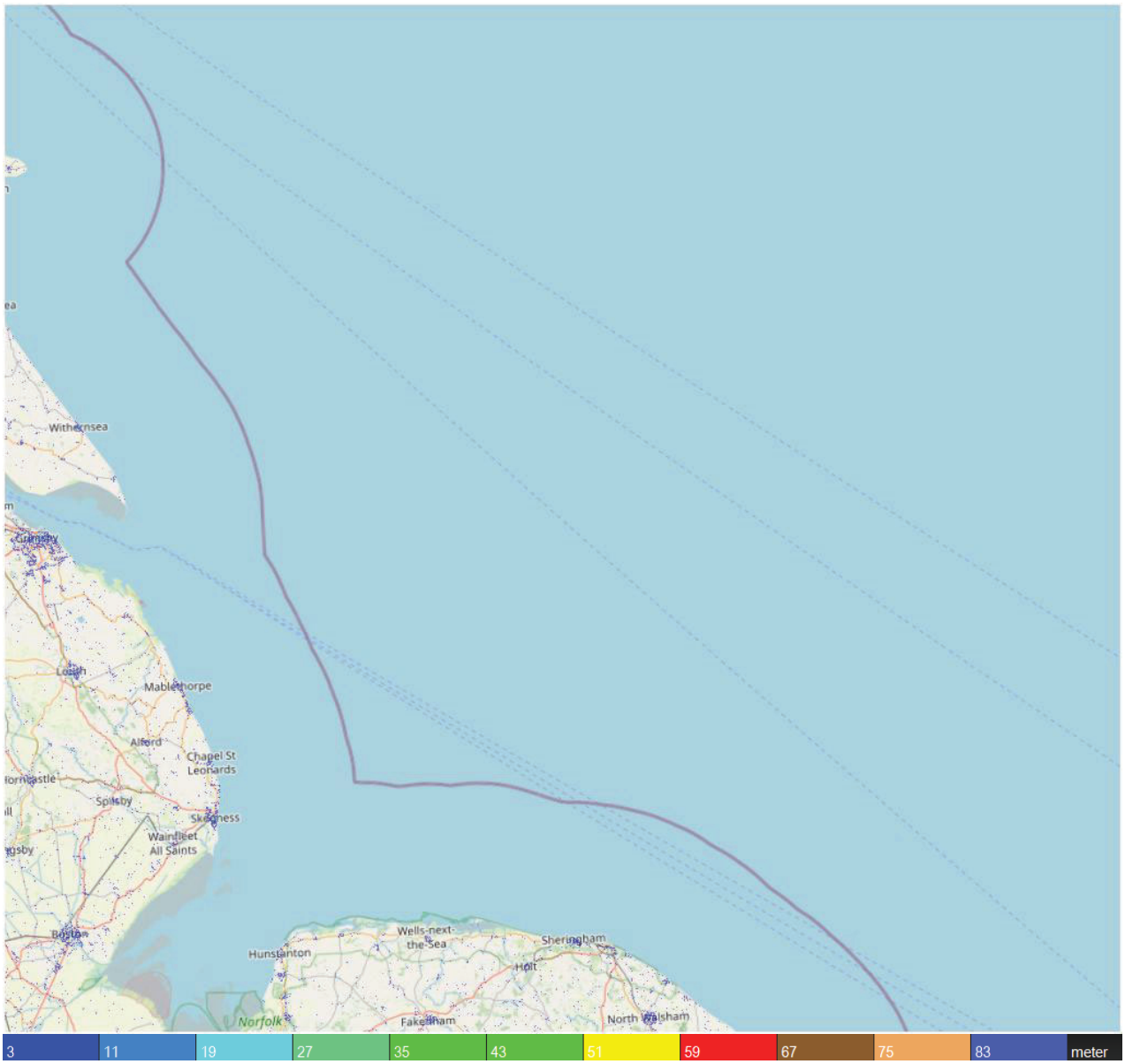
The different layers are described below.




DTM layer




Clutter Layer




Building Layer

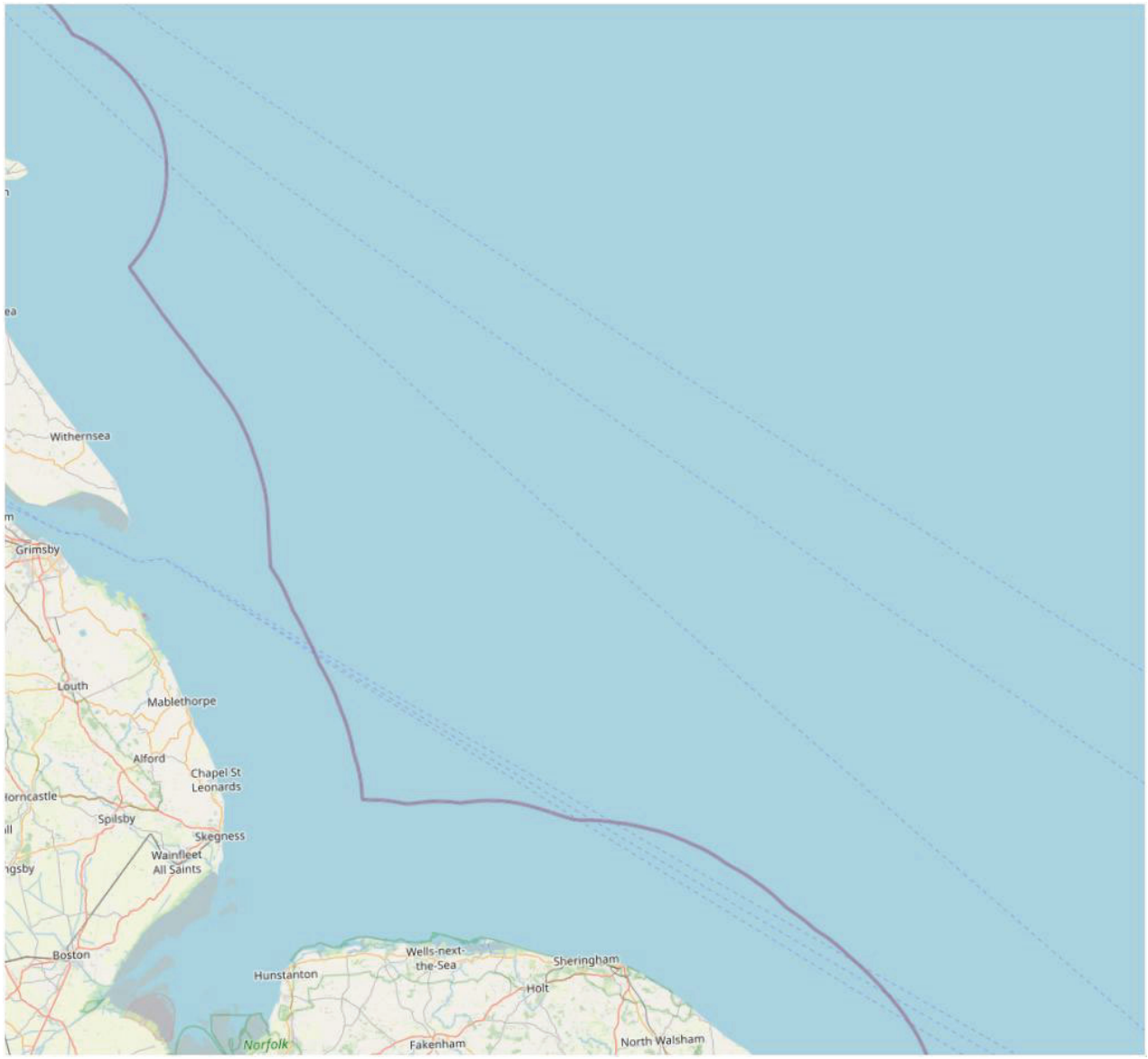
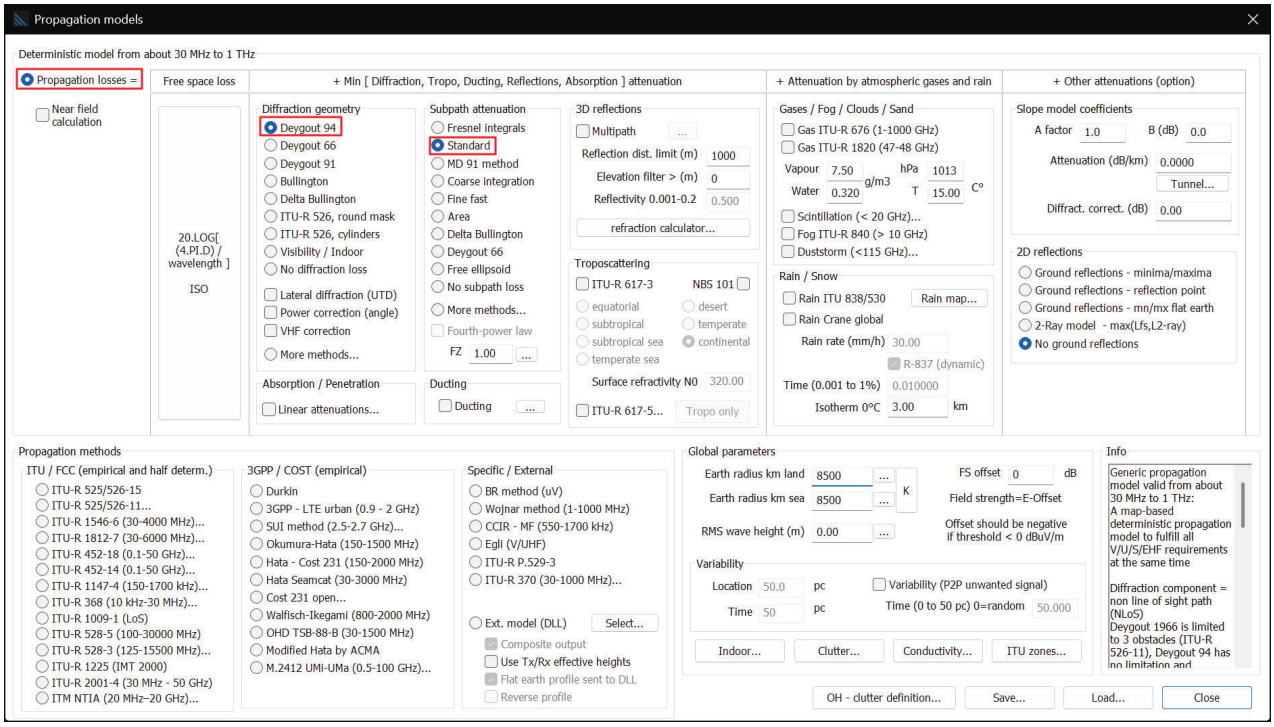


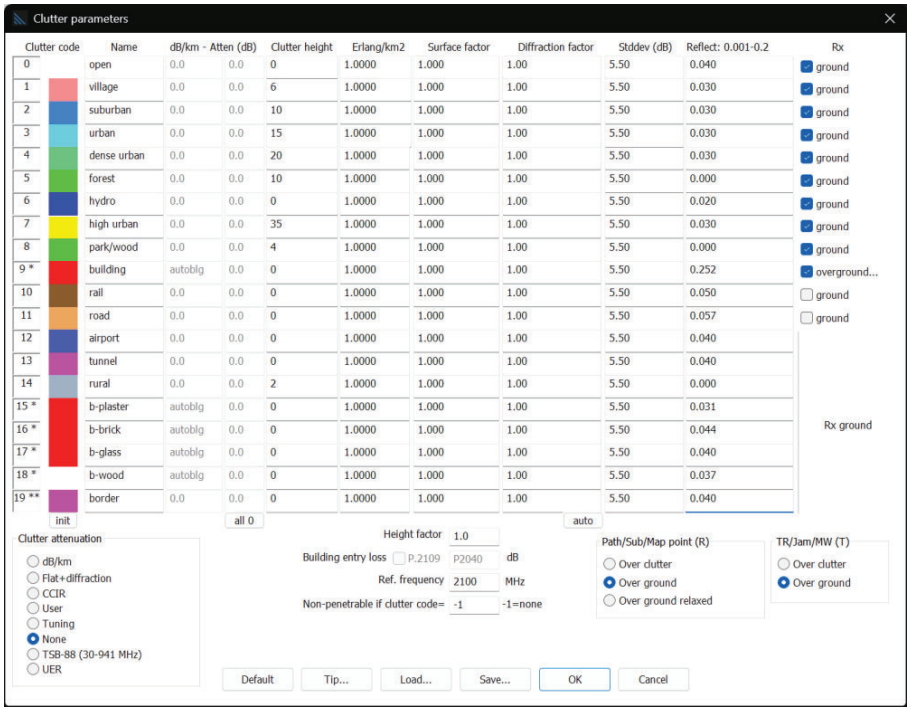

Image Layer (Bing[tm])

## 4. Simulation parameters

The propagation model considered is the visibility model of HTZ communications including subpath losses with the following settings.




Clutter settings

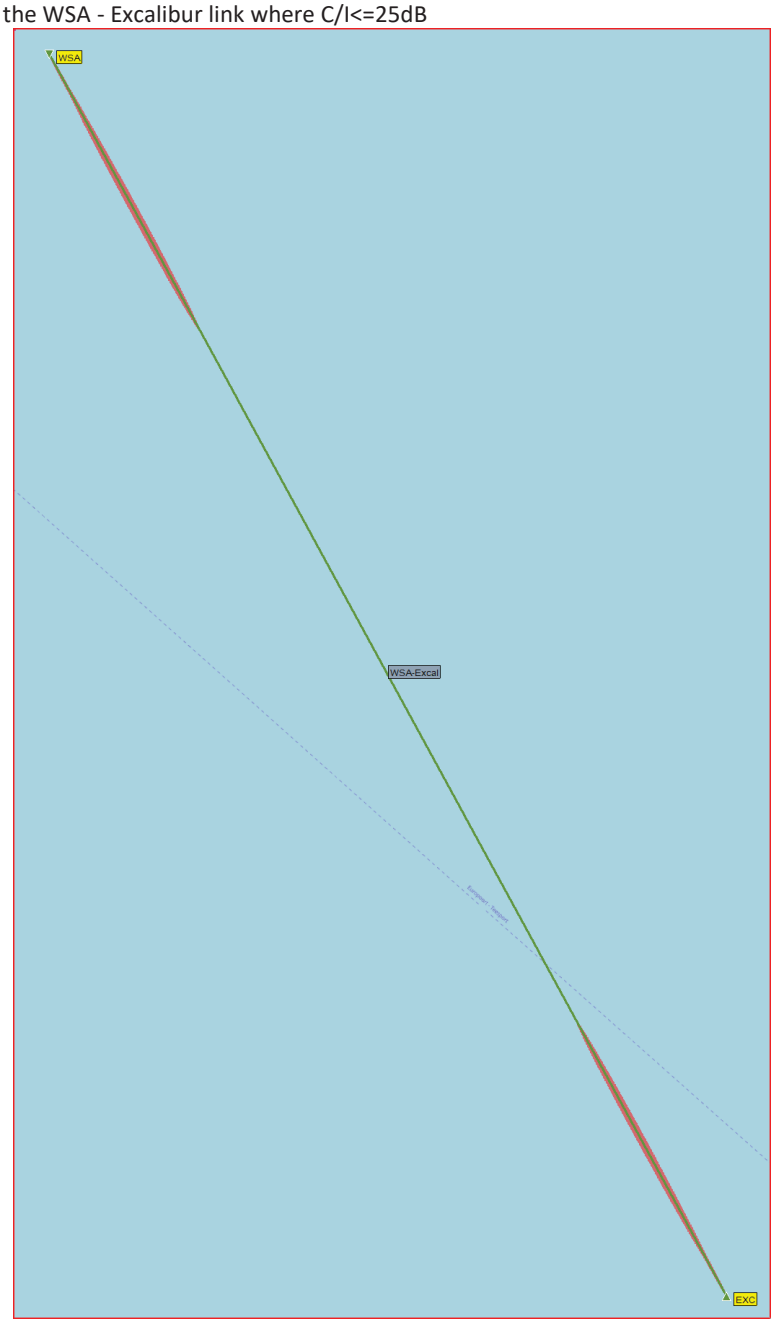


## 5. Exclusion areas for each MW link

The exclusion areas around each MW link has been created and the results are provided in the next sub-sections.
An exclusion area is made of WT locations where the C/I value received by at least one MW link head is greater than 25dB.
I is the interfering signal coming from reflections on the virtual WT.
C is wanted power received by the MW link head.

### 5.1. WSA - Excalibur link

Exclusion area around the WSA - Excalibur link where C/I<=25dB

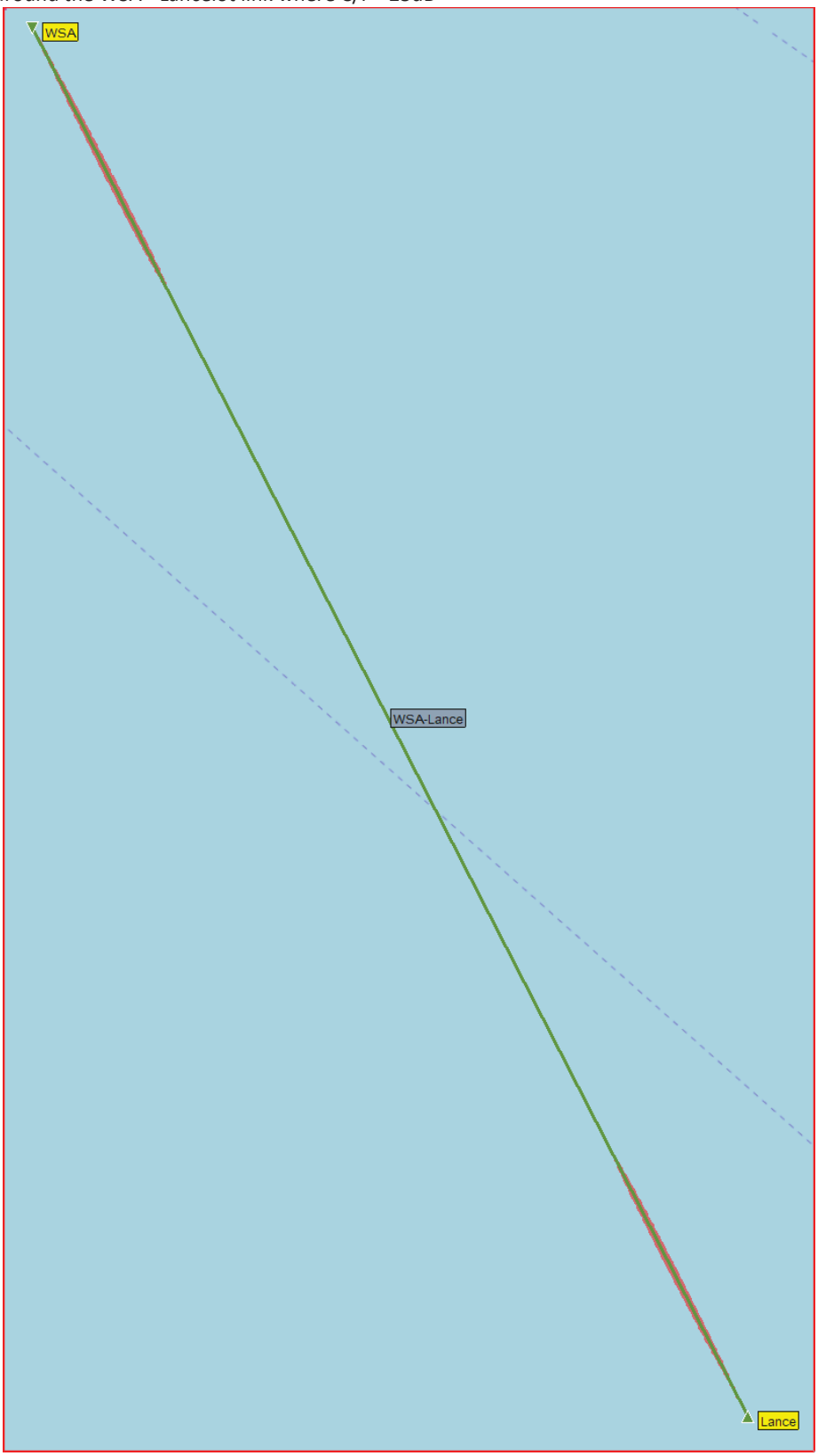


Zoom

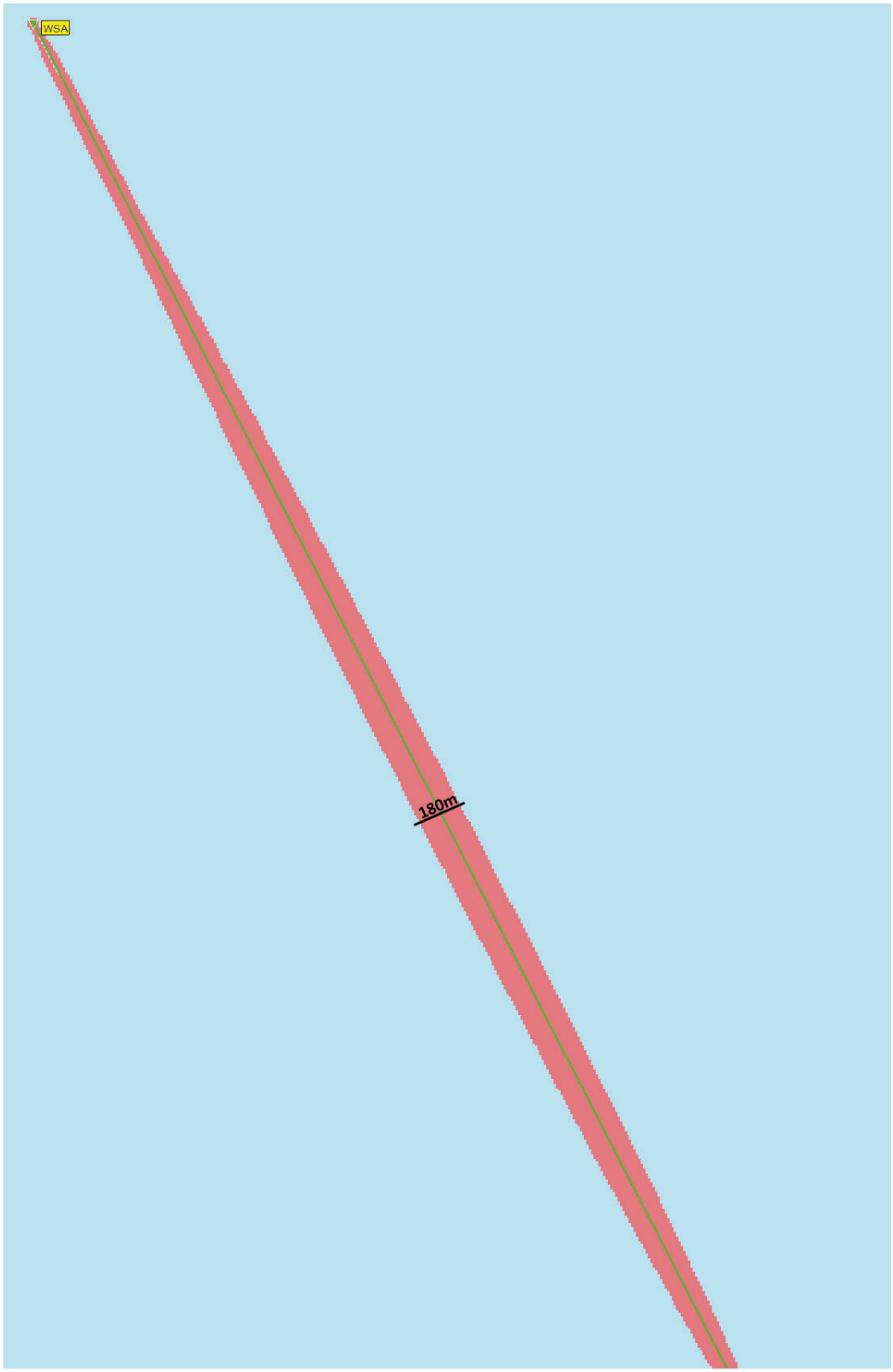

The largest width of the exclusion area is 170m. The maximum radius around the LOS is 170/2=85m.

## 5.2. WSA - Lancelot link

Exclusion area around the WSA - Lancelot link where C/I<=25dB



Zoom




The largest width of the exclusion area 180m. The maximum radius around the LOS is 180/2=90m.

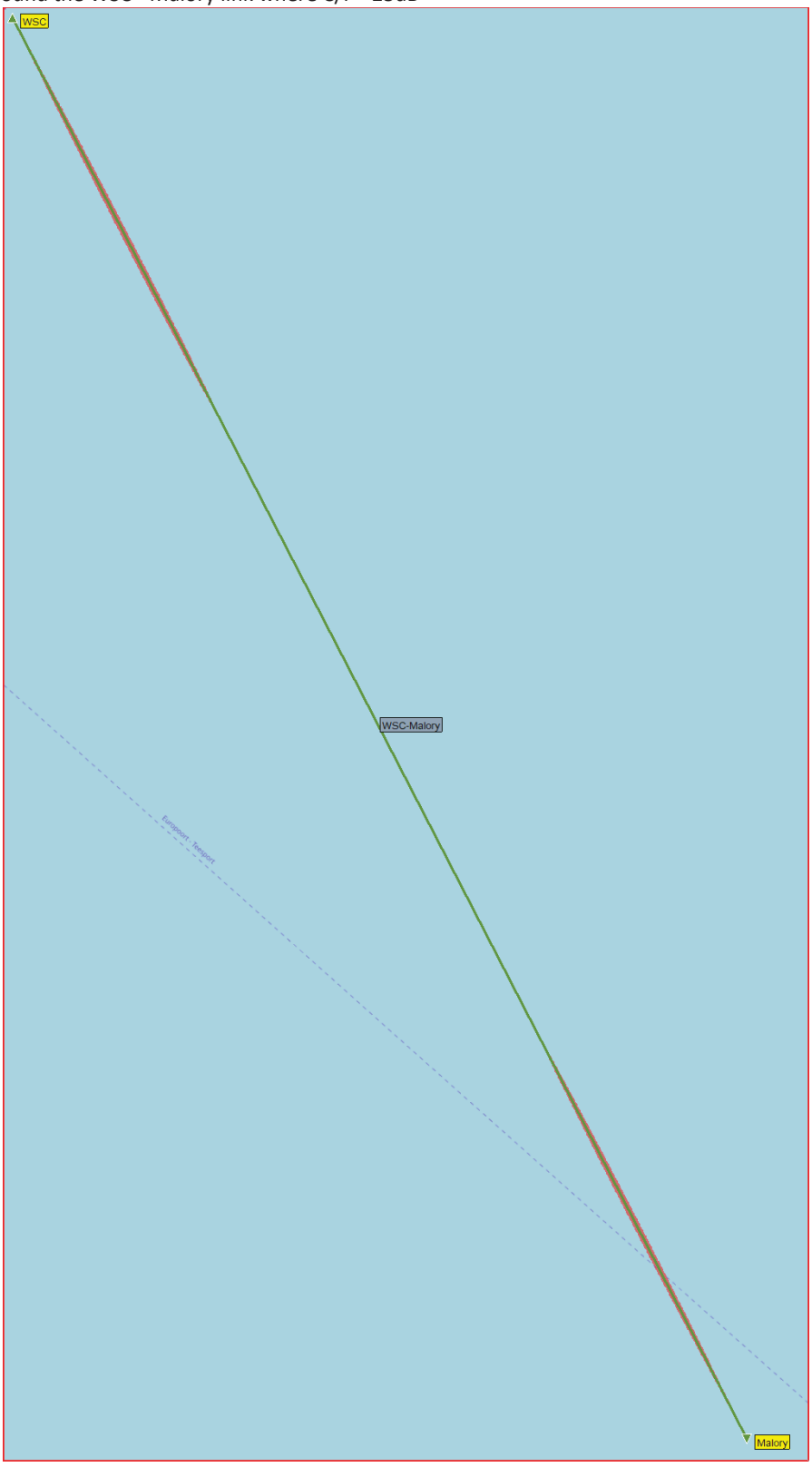
## 5.3. WSA - Malory link

Exclusion area around the WSA - Malory link where C/I<=25dB

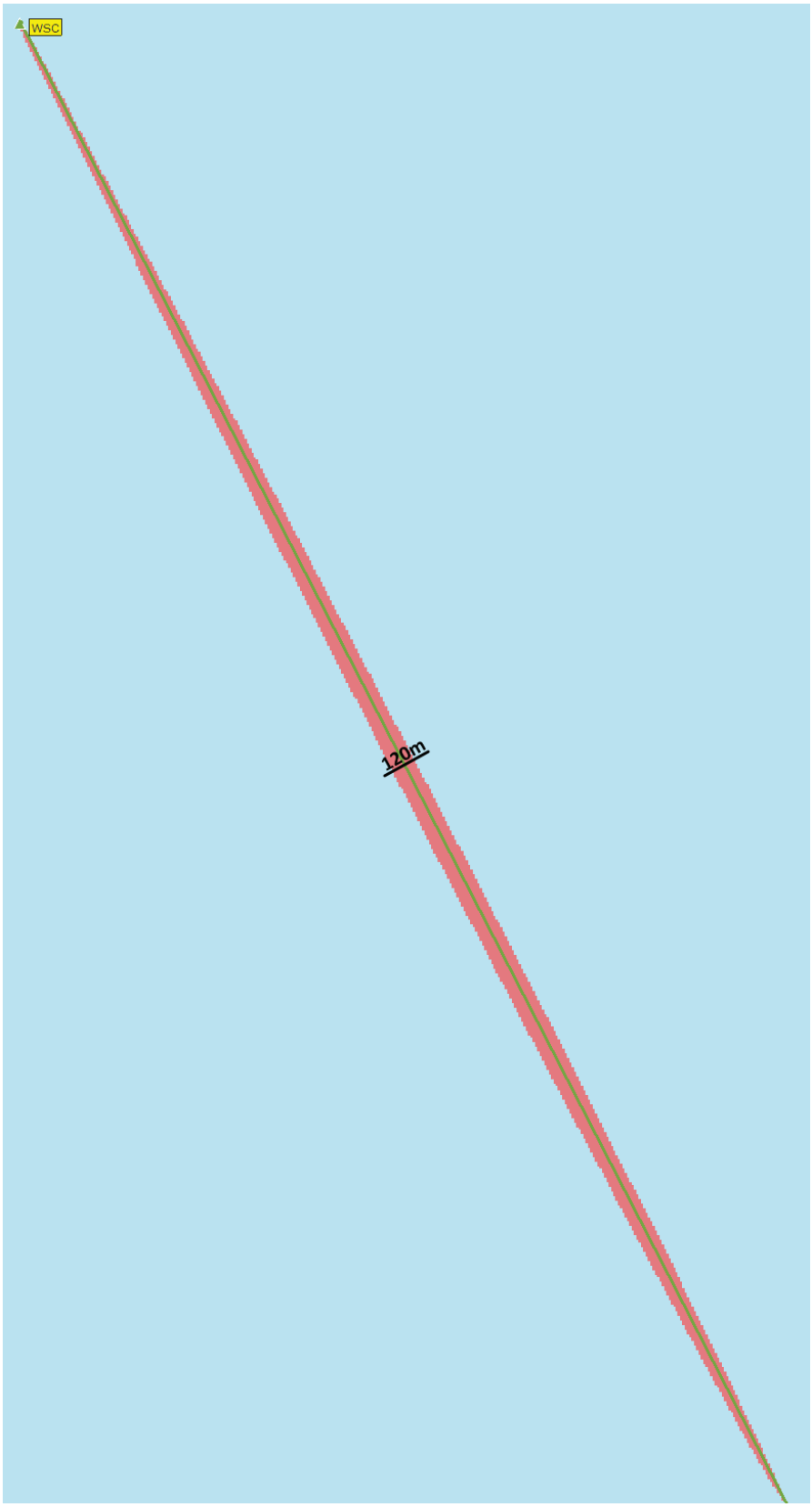

The largest width of the exclusion area is 360m. The maximum radius around the LOS is 360/2=180m.

## 5.4. WSC - Malory link

Exclusion area around the WSC - Malory link where C/I<=25dB



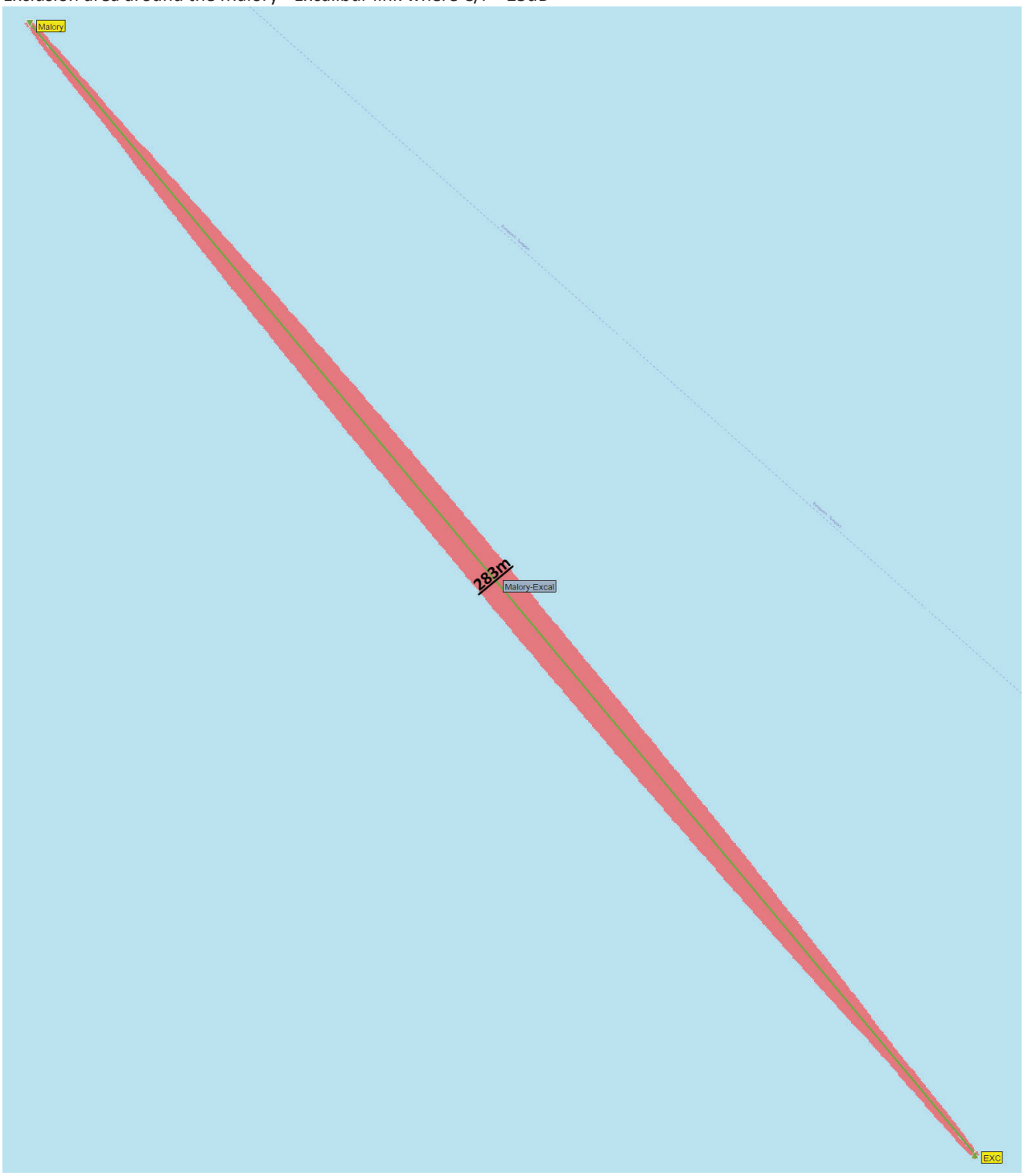
Zoom




The largest width of the exclusion area is 120m. The maximum radius around the LOS is 120/2=60m.

## 5.5. Malory - Excalibur link

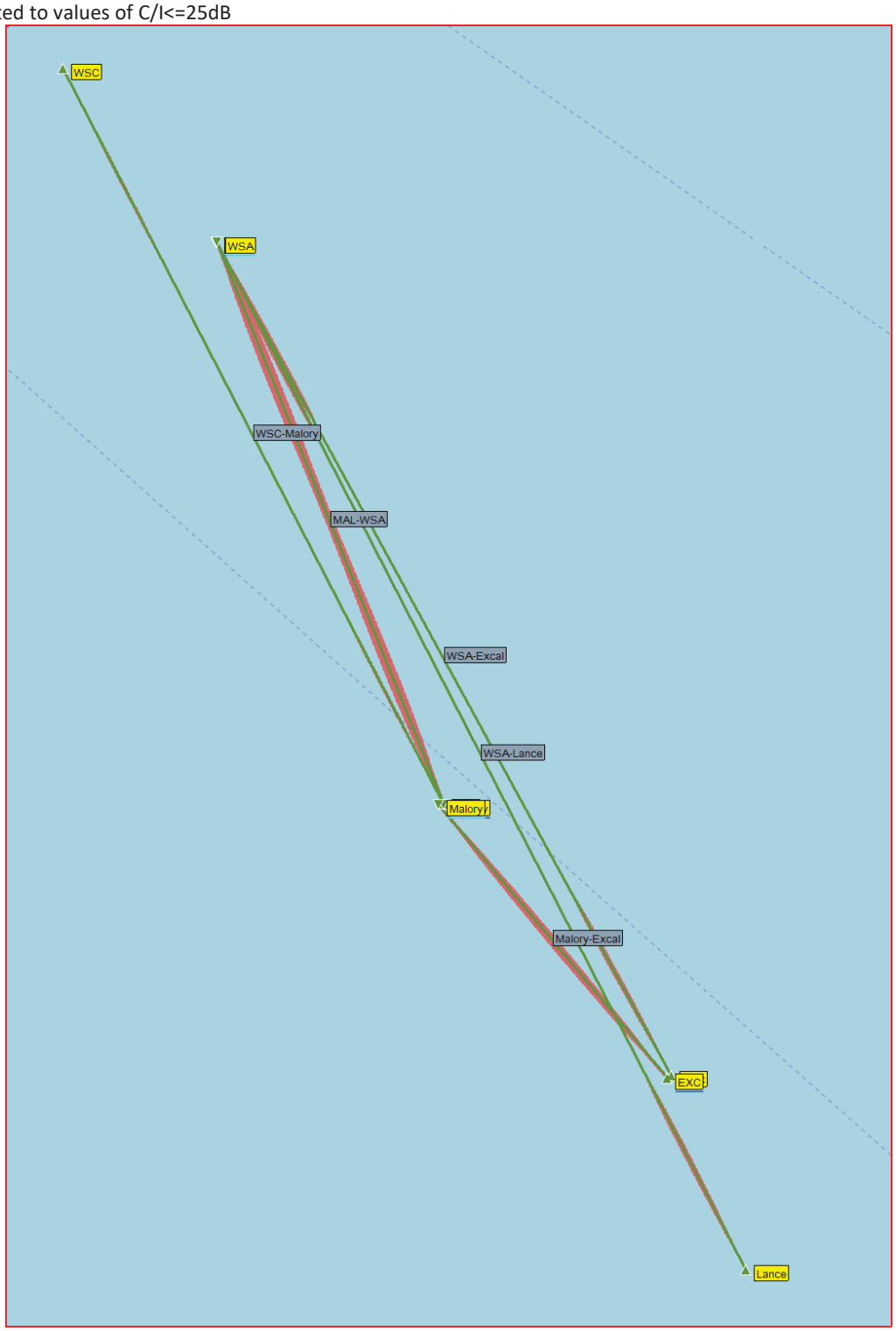
Exclusion area around the Malory - Excalibur link where C/I<=25dB




The largest width of the exclusion area is 283m. The maximum radius around the LOS is 283/2=141.5m.

## 6. Exclusion areas for all MW links

Combination of all exclusion areas built for each MW link has also been performed, considering the worst case (maximum interference level) found on each point.
Areas limited to values of C/I<=25dB



## 7. Conclusion

The largest widths of the exclusion area for each link are listed in the below table:

| Link Ident | Largest width of the exclusion area (m) | Maximum Radius around the LOS (m) |
|---|---|---|
| WSA - Excalibur | 170 | 85 |
| WSA - Lancelot | 180 | 90 |
| WSA - Malory | 360 | 180 |
| WSC - Malory | 120 | 60 |
| Malory - Excalibur | 283 | 141.5 |

Note: Achieving a C/I >=25dB doesn't guaranty that the link won't be interfered and the reliability not reduced.
With a high interference level (I), even if the wanted signal (C) is 25dB higher than (I), the threshold degradation will be high.

Example:

| | |
|---|---|
| C (dBm) | -55 |
| I (dBm) | -80 |
| Noise (dBm) | -101 |
| I/N (dB) | 21 |
| Threshold degradation (dB) | 21 |