Technical Appendix 16.1: Aviation Assessment

Cloiche Wind Farm

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ACL Aviation Certification Quality Assured ISO 9001 UKAS MANAGEMENT SYSTEMS 4565

Executive Summary

Cyrrus Limited has been engaged by SSE Generation Limited to consider potential aviation impacts associated with the proposed Cloiche Wind Farm development.

Radar modelling of the finalised layout of 36 turbines of 149.9m tip height against radars in the immediate and wider areas shows the following:

- Radar Line of Sight (RLoS) does not exist between Inverness Radar and Cloiche Wind Farm;
- Path loss and Probability of Detection calculations confirm that the Inverness Primary Surveillance Radar (PSR) is highly unlikely to detect turbines in the finalised layout;
- RLoS does not exist between Lossiemouth Radar and Cloiche Wind Farm;
- RLoS does not exist between the NATS (En Route) plc PSRs at Allanshill, Perwinnes and Tiree and Cloiche Wind Farm;
- RLoS does not exist between the Ministry of Defence (MoD) Air Defence Radars at Benbecula and Buchan and Cloiche Wind Farm.

Assuming the turbines have a maximum tip height of 3,000ft Above Mean Sea Level, the area surrounding Cloiche Wind Farm is clear of any controlled airspace and any significant aviation activity apart from Low-Level Flying Area 14 and the Area of Intense Gliding Activity to the east in the vicinity of Feshiebridge. It is anticipated that the MoD, and other aviation stakeholders as required, would be consulted on the Proposed Development during the determination period. The Applicant would agree a suitable aviation lighting scheme with the MoD in accordance with MoD obstruction lighting guidance.

Abbreviations

AD	Air Defence
AGL	Above Ground Level
AMSL	Above Mean Sea Level
AOD	Above Ordnance Datum
ATS	Air Traffic Service
CAA	Civil Aviation Authority
DEM	Digital Elevation Model
DTM	Digital Terrain Model
EIA	Environmental Impact Assessment
FL	Flight Level
GIS	Geographic Information System
HIAL	Highlands and Islands Airports Limited
LFA	Low Flying Area
MoD	Ministry of Defence
NERL	NATS (En Route) plc
PD	Probability of Detection
PinS	Position-in-Space
PSR	Primary Surveillance Radar
RAF	Royal Air Force
RCS	Radar Cross Section
RLoS	Radar Line of Sight
SRTM	Shuttle Radar Topography Mission
VFR	Visual Flight Rules
VPD	Vertical Polar Diagram

Contents

List of figures

List of tables

1. Introduction

1.1. Background

1.1.1. SSE Generation Limited is proposing to construct a new onshore wind farm located on Glendoe and Garrogie Estates, on a high mountain plateau approximately 11km South East of Fort Augustus. Cloiche Wind Farm, the Proposed Development, will comprise 36 turbines with a tip height of 149.9m. The development location is adjacent to Stronelairg Wind Farm which is currently under construction.

1.1.2. Cyrrus Limited has been engaged to address the aviation issues arising from the planned development of Cloiche Wind Farm.

1.2. Effects of Wind Turbines on Aviation

1.2.1. Wind turbines can be problematic for aviation Primary Surveillance Radars (PSRs) as the characteristics of a moving wind turbine blade are similar to an aircraft. The PSR is unable to differentiate between wanted aircraft targets and clutter targets introduced by the presence of turbines.

1.2.2. The significance of any radar impacts depends on airspace usage in the vicinity of the wind farm site and the nature of the Air Traffic Service (ATS) provided in that airspace.

1.3. Scoping Report

1.3.1. The Scoping Report[1] identifies the closest civilian and military airfields to the development site as Inverness Airport and Royal Air Force (RAF) Lossiemouth respectively. Both these airfields have operational radar facilities and following consultation Highlands and Islands Airports Limited (HIAL) have requested a Radar Line of Sight (RLoS) modelling assessment of the possible effect of the turbines on Inverness Airport's radar performance.

1.3.2. There are three NATS (En Route) plc (NERL) PSRs within the wider area: Allanshill, Perwinnes and Tiree. The closest Ministry of Defence (MoD) Air Defence (AD) radars are at Buchan and Benbecula.

1.4. Aviation Assessment Tasks

1.4.1. The assessment tasks identified are:

- Determine the radar visibility of Cloiche Wind Farm to Inverness Airport's radar;
- Determine the radar visibility of Cloiche Wind Farm to other radars in the wider area;
- Review the nature of the airspace in the vicinity of Cloiche Wind Farm to determine potential impacts to aviation.

1.4.2. This initial work is detailed in this report and will shape the subsequent consultation and mitigation strategies to be adopted.

[1] Cloiche Wind Farm Scoping Report, August 2018

2. Data

2.1. The data in the following paragraphs has been used for the RLoS modelling undertaken in this report.

2.2. Cloiche Wind Farm

2.2.1. A finalised layout for Cloiche Wind Farm developed through the EIA process has been supplied as a geo-referenced Shapefile.

2.2.2. This layout consists of 36 wind turbines. The proposed turbines will be three bladed horizontal downward axis machines with a blade (rotor) diameter of circa 136m and a total maximum blade tip height of 149.9m Above Ground Level (AGL). Ground elevations at the turbine sites vary from 633m Above Ordnance Datum (AOD) to 752m AOD.

2.3. Inverness Airport Radar

2.3.1. HIAL have requested that the following radar data is used for the RLoS assessment:

- Inverness Radar OS Grid Reference 276977.56E 852598.07N;
- Height of radar head 31.4m AOD.

2.3.2. Inverness Radar is a Thales Star 2000/RSM 970 S PSR/Secondary Surveillance Radar (SSR) facility.

2.4. Terrain Data

2.4.1. Terrain data:

- Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) 1 arc second resolution;
- NextMap 25m Digital Terrain Model (DTM).

2.5. Analysis Tools

- ATDI ICS telecom EV v15.4.3 x64 radio network analysis tool;
- Blue Marble Global Mapper v21.0.0 Geographic Information System (GIS) application tool;
- ZWCAD+ 2015 SP1 Pro v2014.11.27(26199).

2.5.1. Ordnance Survey National Grid Reference (OSGB36) is used as a common working datum for all mapping and geodetic references.

2.5.2. Mapping datum transformations are made using Global Mapper or Grid InQuest II Coordinate Transformation Program (OSTN15).

3. Cloiche Wind Farm Location

3.1. The Proposed Development area is outlined in Figure 1. The red crosses depict the wind turbine layout. Also shown are the Stronelairg operational turbines and access tracks.

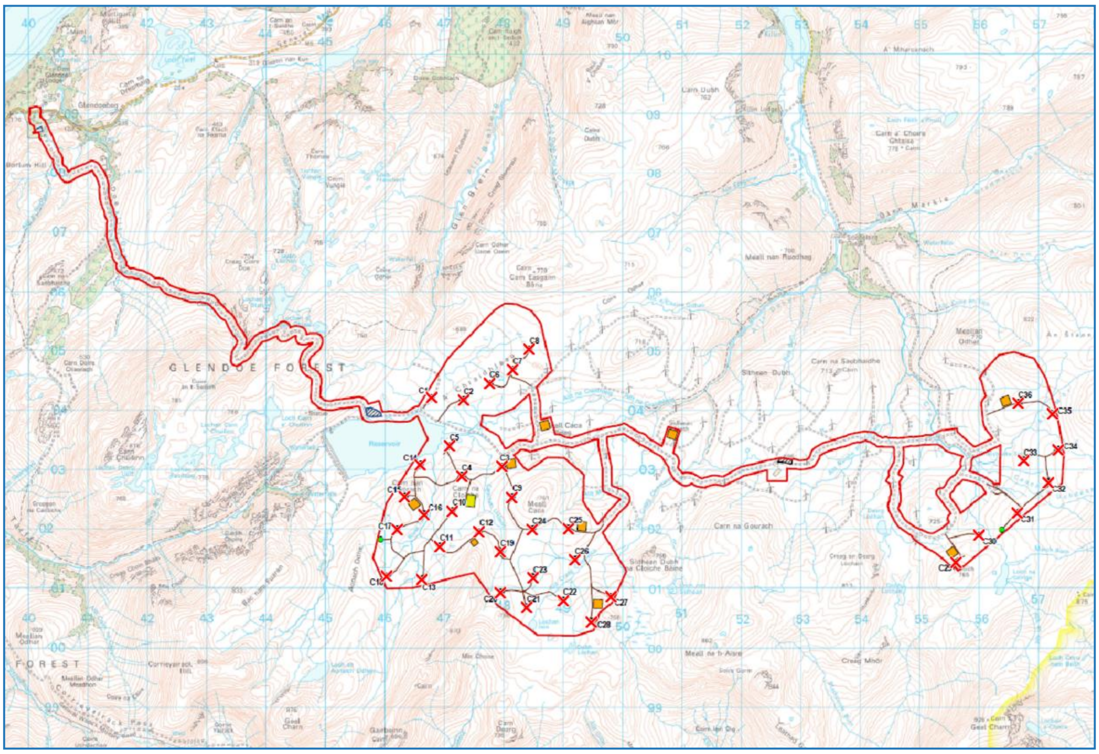

Figure 1: Cloiche Wind Farm location

3.2. The finalised 36 turbine layout used for the modelling is shown in more detail in Figure 2.

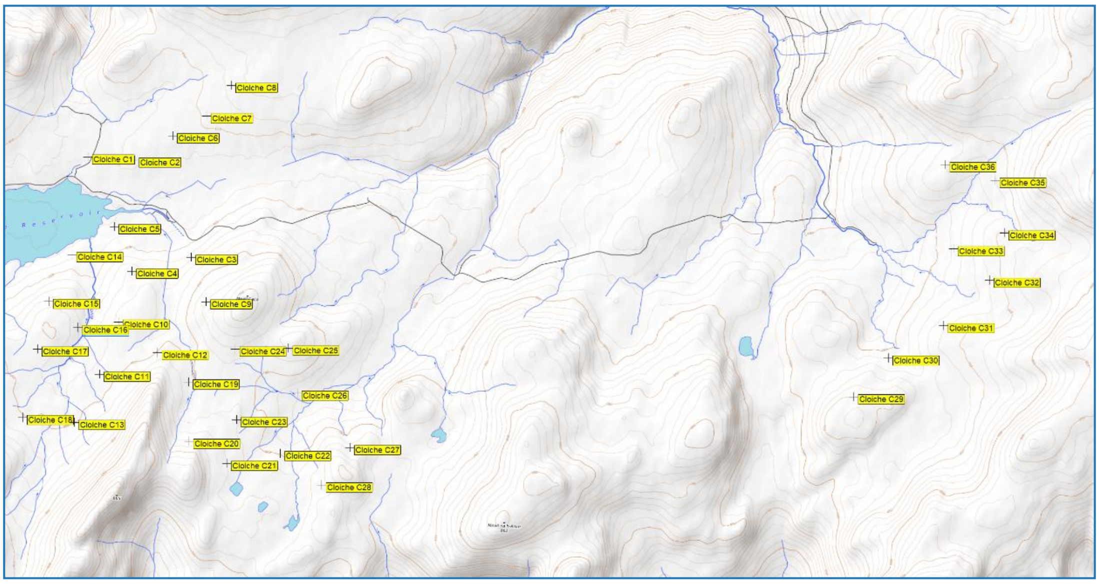

Figure 2: Indicative turbine layout

4. Radar Modelling

4.1. Inverness Radar

4.1.1. At its closest point the Proposed Development area is 52km from Inverness Radar. The relative locations of Cloiche Wind Farm and Inverness Radar are shown in Figure 3.

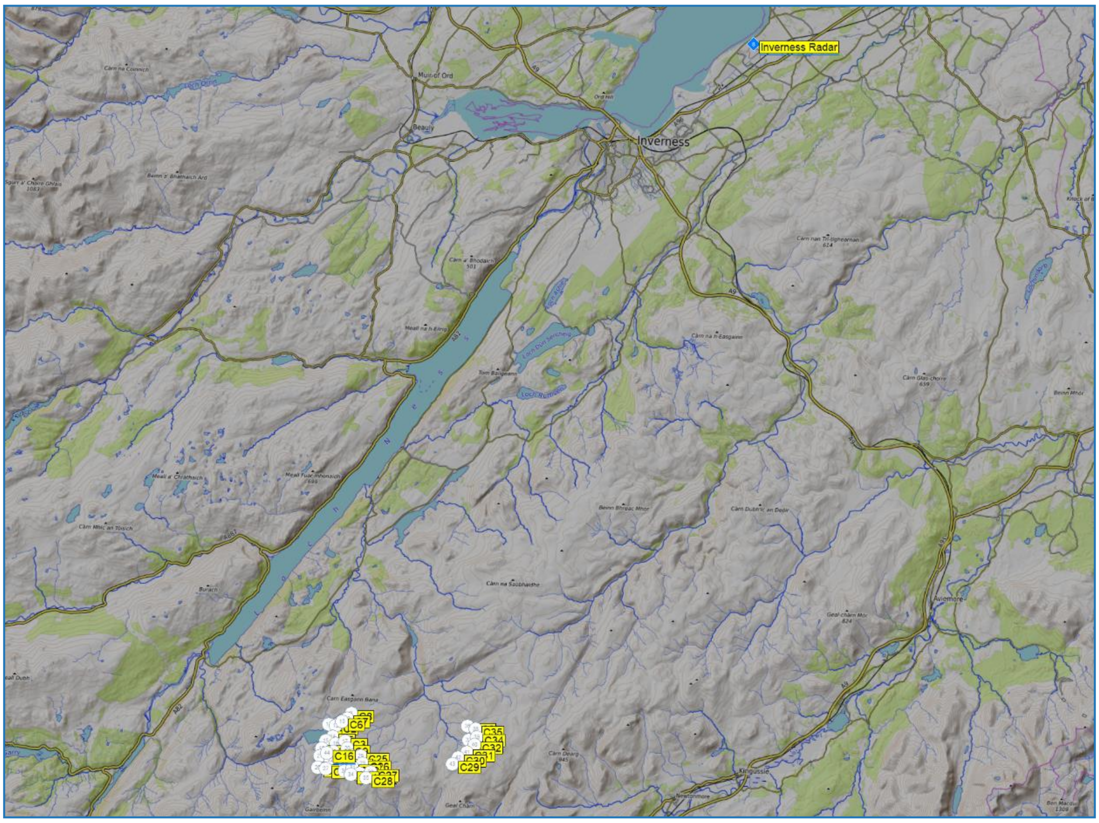

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Figure 3: Location of Inverness Radar and Cloiche Wind Farm

4.1.2. RLoS is determined from a radar propagation model (ATDI ICS telecom EV) using 3D NextMap DTM data with 25m horizontal resolution. Radar data is entered into the model and RLoS to the turbines from the radar is calculated.

4.1.3. Note that by using a DTM no account is taken of possible further shielding of the turbines due to the presence of structures or vegetation that may lie between the radar and the turbines. Thus, the RLoS assessments are worst-case results.

4.1.4. For PSR, the principal source of adverse effects are the turbine blades, so RLoS is calculated for the maximum tip height of the turbines, i.e. 149.9m AGL.

4.1.5. A 3D view of the turbines and the terrain model is shown in Figure 4.

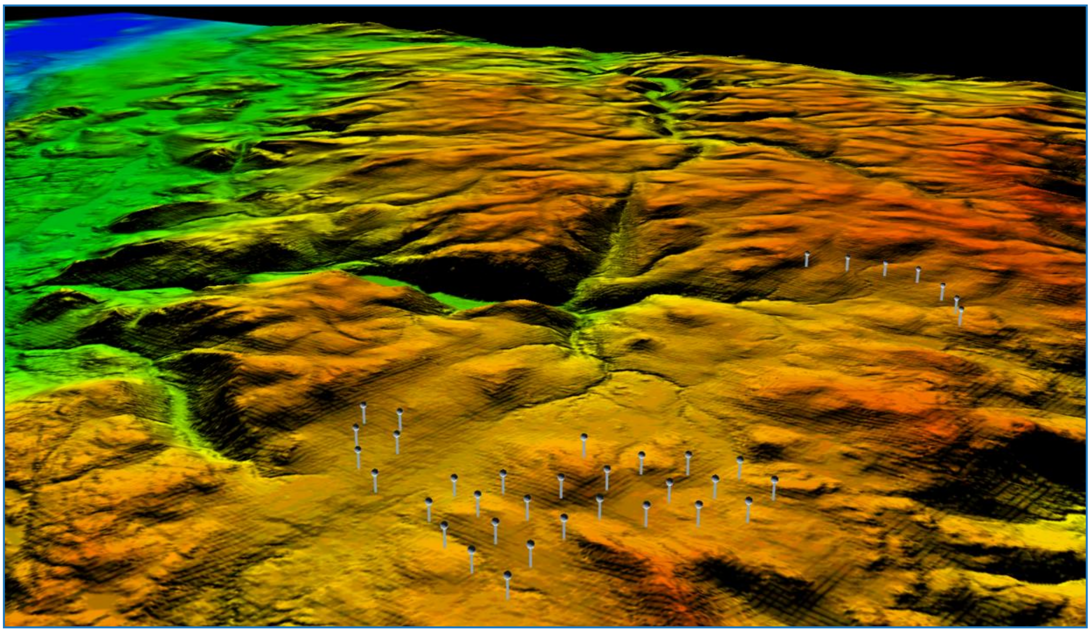

Figure 4: 3D view of turbines and terrain

4.1.6. The magenta shading in Figure 5 illustrates the RLoS coverage from Inverness Radar to turbines with a blade tip height of 149.9m AGL.

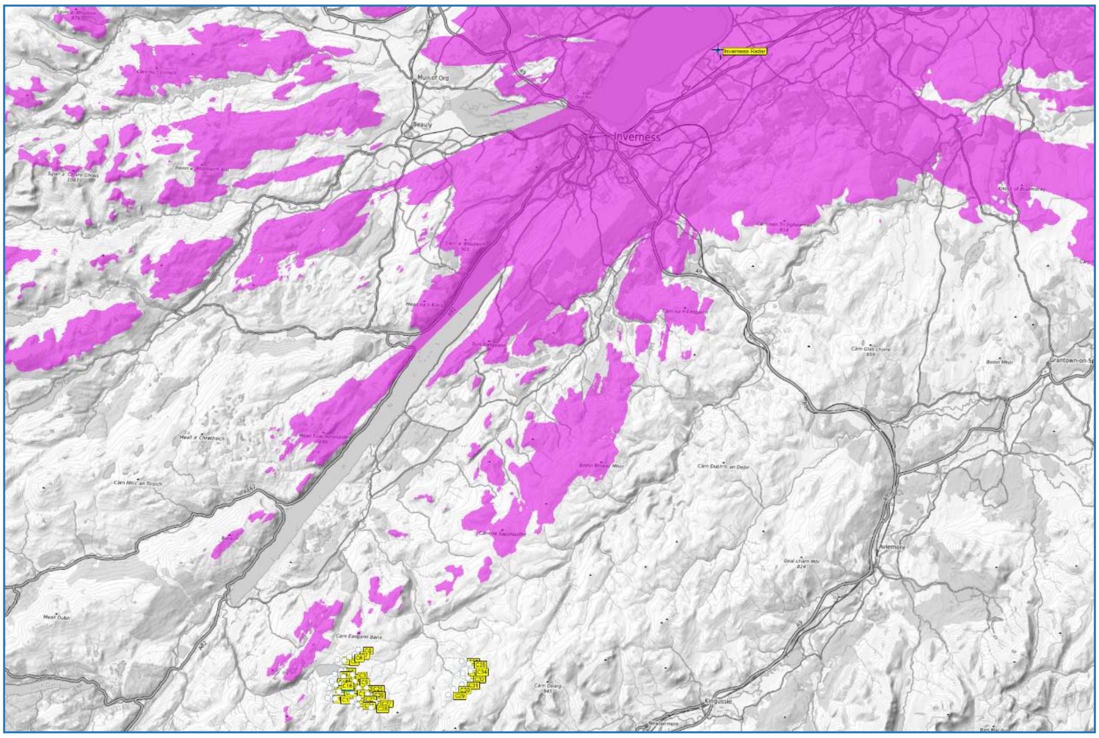

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Figure 5: Inverness Radar RLoS to 149.9m AGL

4.1.7. The zoomed view of the wind farm in Figure 6 shows that RLoS does not exist between Inverness Radar and any of the turbines in the finalised layout. The closest turbines to areas of 149.9m RLoS coverage are turbines C1 and C8.

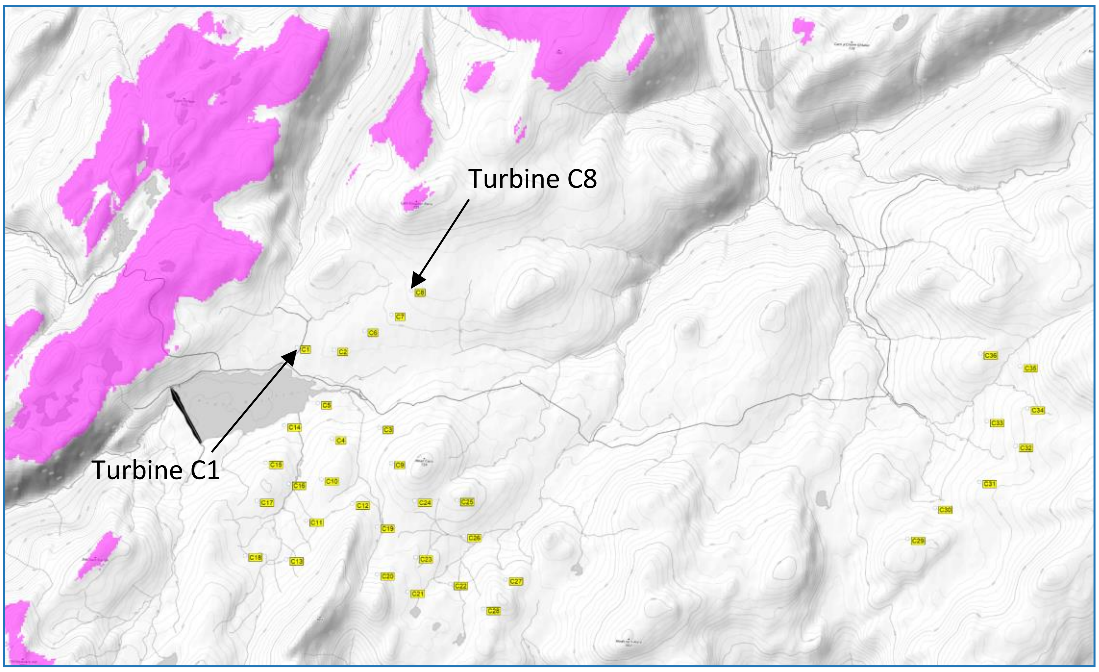

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Figure 6: Inverness Radar RLoS to 149.9m AGL – zoomed

4.1.8. When no RLoS exists, it can generally be assumed that the radar will not detect the turbines. However, this can only be assured by analysis of path profiles between the radar and each turbine and conducting Probability of Detection (PD) calculations.

4.1.9. The profile between Inverness Radar and the tip of turbine C1 is shown in Figure 7.

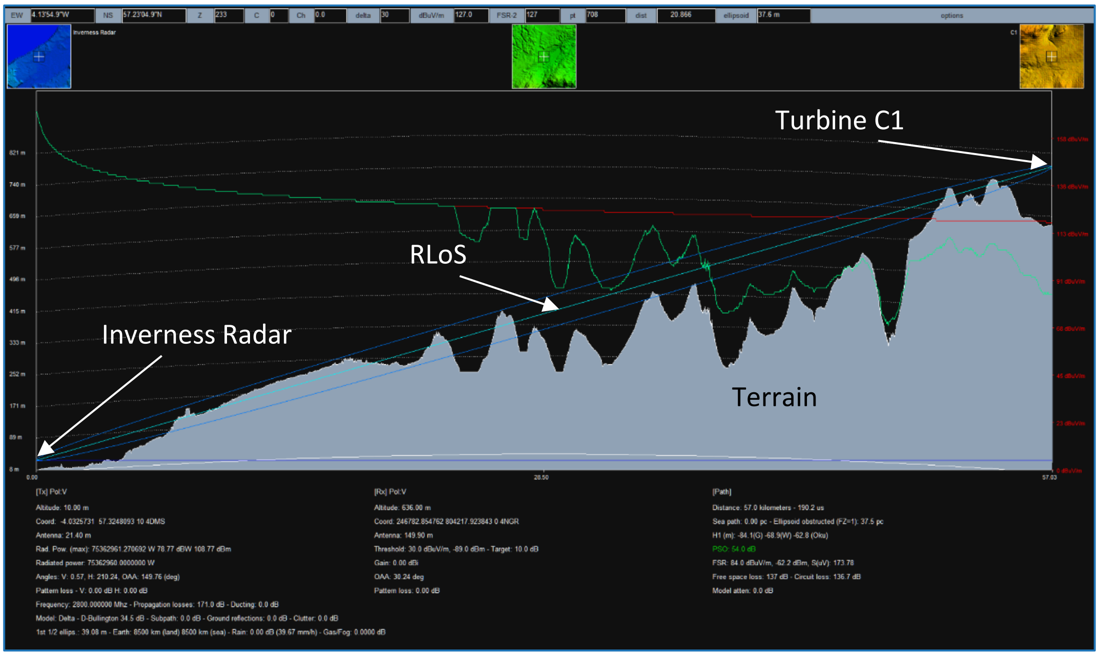

Figure 7: Path profile between Inverness Radar and turbine C1

4.1.10. Path profiles between Inverness Radar and all 36 turbines are shown in Annex A.

4.1.11. Although Figure 7 confirms that intervening terrain blocks RLoS between the radar and turbine C1, the probability that the turbine will be detected by the radar is still dependant on several factors including the radar's power, the angle of antenna tilt and distance to the object.

4.1.12. The radar propagation model can determine the actual path loss between the PSR and various parts of the turbine. By knowing the PSR transmitter power, antenna gain, 2-way path loss, receiver sensitivity and the turbine Radar Cross Section (RCS) gain, the probability of the radar detecting the target (PD) can be calculated.

4.1.13. The static parts of the turbine (tower structure) are ignored in the calculation as these will be rejected by the radar Moving Target filter. In this refined model, 3 parts of the turbine blade are considered: the hub, the blade tip, and a point midway along the turbine blade. Each part of the turbine blade is assigned an RCS of 50m^2 based on a blade length of 68m (half of 136m rotor diameter). Path loss calculations are made to all turbines. The received signal at the radar from each component part of the turbine is then summed to determine the total signal level.

4.1.14. The path loss calculation carried out for each turbine component is as follows:

	Tx Power	dBm
+	Antenna Gain	dB
-	Path Loss	dB
+	RCS Gain	dB (50m^2 ~ +47dB)
-	Path Loss	dB
+	Antenna Gain	dB
=	Received Signal	dBm

4.1.14.1. The received signal is then compared with the radar receiver Minimum Detectable Signal level.

4.1.15. An example of the calculation from Inverness PSR to turbine C1 is shown in Figure 8.

Radar 2-Way Path Loss Calculator

Data		
Tx Frequency	2800	MHz
Tx Power	28000	Watts
Antenna Gain	34.3	dBi
Rx Sensitivity	-125	dBm
Target		
RCS	50	m^2
Path Loss (1-way)	171	dB
Calculations		
Tx Wavelength	0.11	m
Tx power	74.47158	dBm
EIRP	108.7716	dBm
Power at Target	-62.2284	dBm
RCS Gain	47.39	dB
Power at Rx	-151.54	dBm
dB over Rx Threshold	-26.54	dB

Figure 8: Path loss calculation for turbine C1

4.1.16. The two-way path losses from the turbine components are tabulated and combined to give total radar received signals from each turbine. The 'dB over RX Threshold' results indicate the likelihood of detection. Radar returns >3dB above the detection threshold have a high probability of detection. Those between +3dB and -3dB indicate a possibility of detection. Radar returns between -3dB and -6dB indicate only a small possibility of detection. Signals that are >6dB below the threshold of detection are unlikely to be detected.

4.1.17. The results of the PD calculations for each turbine are shown in Table 1, which indicates that all of the 36 turbines are unlikely to be detected by Inverness PSR.

	Turbine Nacelle	Blade mid-point	Blade Tip	TOTAL
Turbine ID	Path Loss dB	Path Loss dB	Path Loss dB	dB over RX threshold
1	180.3	177.2	171.0	-26.24
2	182.3	179.5	174.6	-33.19
3	179.1	177.0	174.2	-31.54
4	179.2	177.0	174.2	-31.55
5	182.5	180.3	177.1	-37.56
6	181.6	178.0	172.9	-29.87
7	180.2	177.1	172.9	-29.62
8	179.2	176.2	170.6	-25.34

Turbine ID	Turbine Nacelle	Blade mid-point	Blade Tip	TOTAL
	Path Loss dB	Path Loss dB	Path Loss dB	dB over RX threshold
9	175.6	171.0	169.4	-21.47
10	178.6	176.6	173.9	-30.87
11	178.5	176.5	174.0	-30.95
12	178.1	175.5	174.2	-26.22
13	178.2	176.3	173.8	-30.53
14	182.6	180.6	177.9	-38.87
15	179.3	176.1	170.4	-24.97
16	179.2	177.2	174.3	-31.78
17	178.9	175.7	171.1	-26.14
18	178.6	176.4	173.4	-30.06
19	176.6	174.7	173.2	-28.61
20	177.2	176.1	174.8	-31.39
21	178.8	177.9	176.9	-35.22
22	178.5	177.4	176.4	-34.30
23	179.0	178.1	177.1	-35.62
24	176.7	175.5	174.0	-30.01
25	178.1	177.1	176.0	-33.56
26	179.2	178.3	177.3	-36.02
27	178.9	177.6	176.3	-34.46
28	178.4	177.2	175.8	-33.52
29	180.2	178.4	176.8	-35.86
30	181.3	179.2	178.0	-38.00
31	181.2	178.6	177.0	-36.43
32	181.3	178.1	176.9	-36.01
33	180.8	177.9	176.5	-35.33
34	180.7	177.3	176.1	-34.44
35	179.2	176.7	175.3	-32.86
36	179.5	176.9	174.7	-32.26

Table 1: Inverness PSR PD results

4.1.17.1. The above calculations are based on the optimum performance of the radar, however the gain of a radar antenna in the vertical axis is not uniform with elevation angle. The beam is a complex shape to minimise ground returns by having low gain at elevations close to the horizontal but having high gain at elevations just a few degrees above the horizon.

4.1.17.2. The maximum gain for a Star 2000 antenna usually occurs at an elevation angle of 3° above the horizontal. If the mechanical tilt of the antenna is altered, then the angle of maximum gain will change by a corresponding amount. The mechanical tilt of the antenna is set at the commissioning of the radar to achieve the best compromise between suppressing ground returns and detecting low altitude aircraft targets. Gain falls off rapidly at lower elevation angles as a function of the antenna Vertical Polar Diagram (VPD). Radar VPD data can be plotted as a smoothed line of elevation versus gain to enable intermediate values of antenna gain to be determined.

4.1.18. The Star 2000 VPD data gives the graph shown in Figure 9.

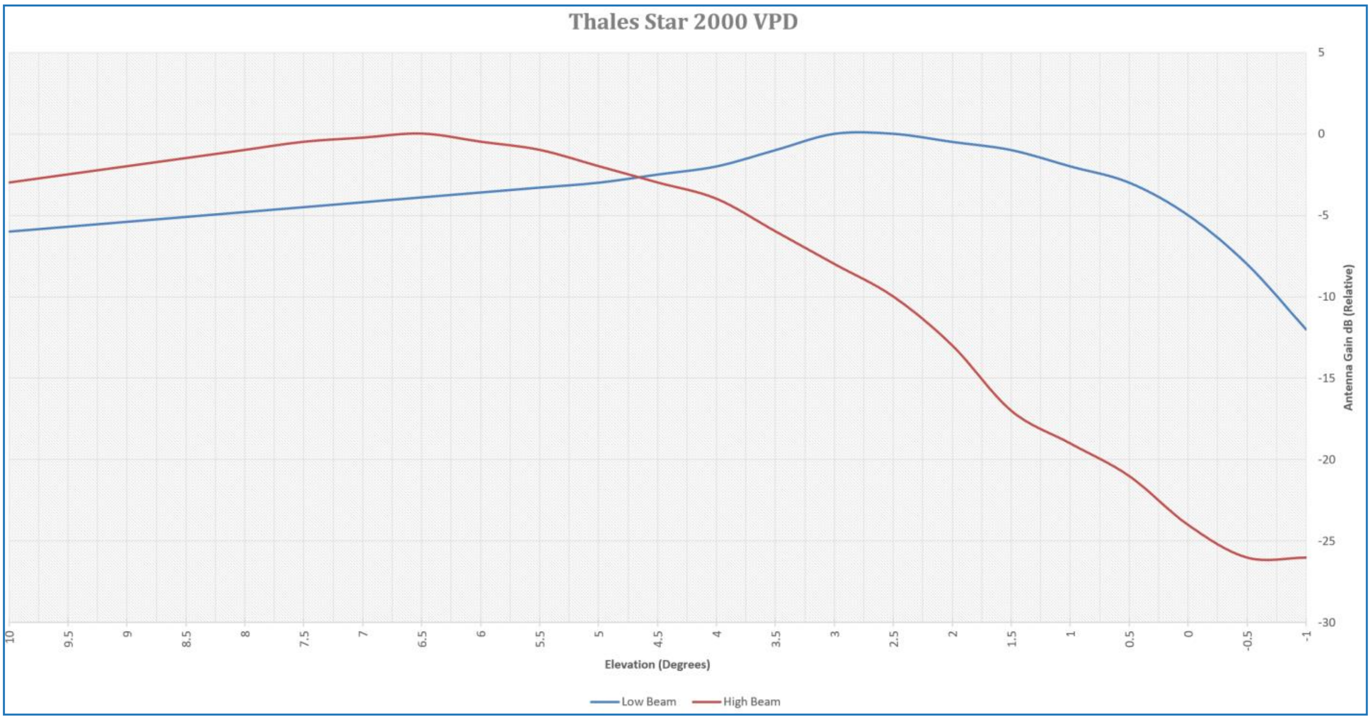

Figure 9: Thales Star 2000 VPD

4.1.19. The Star 2000 is a dual beam antenna. At short ranges the radar uses a high beam to reduce the effects of close in ground clutter. Beyond these ranges a low beam is used. Cloiche Wind Farm lies in Inverness PSR's low beam area.

4.1.20. The vertical angle from Inverness PSR to the tips of the turbines varies between 0.55° and 0.76°. If a 0° mechanical antenna tilt is assumed, this means a low beam gain reduction of approximately -3dB at these elevations.

4.1.21. Table 2 shows the results of the PD calculations incorporating the reduction in antenna gain that occurs for targets off the axis of maximum gain.

	Turbine Nacelle	**Blade mid-point**	**Blade Tip**	**TOTAL**
Turbine ID	Path Loss dB	Path Loss dB	Path Loss dB	dB over RX threshold
1	180.3	177.2	171.0	-33.71
2	182.3	179.5	174.6	-39.19
3	179.1	177.0	174.2	-37.54
4	179.2	177.0	174.2	-37.55
5	182.5	180.3	177.1	-43.56
6	181.6	178.0	172.9	-35.87
7	180.2	177.1	172.9	-35.62
8	179.2	176.2	170.6	-31.34
9	175.6	171.0	169.4	-27.47
10	178.6	176.6	173.9	-36.87
11	178.5	176.5	174.0	-36.95

Turbine ID	Turbine Nacelle	Blade mid-point	Blade Tip	TOTAL
	Path Loss dB	Path Loss dB	Path Loss dB	dB over RX threshold
12	178.1	175.5	171.2	-32.22
13	178.2	176.3	173.8	-36.53
14	182.6	180.6	177.9	-44.87
15	179.3	176.1	170.4	-30.97
16	179.2	177.2	174.3	-37.78
17	178.9	175.7	171.1	-32.14
18	178.6	176.4	173.4	-36.06
19	176.6	174.7	173.2	-34.61
20	177.2	176.1	174.8	-37.39
21	178.8	177.9	176.9	-41.22
22	178.5	177.4	176.4	-40.30
23	179.0	178.1	177.1	-41.62
24	176.7	175.5	174.0	-36.01
25	178.1	177.1	176.0	-39.56
26	179.2	178.3	177.3	-42.02
27	178.9	177.6	176.3	-40.46
28	178.4	177.2	175.8	-39.52
29	180.2	178.4	176.8	-41.86
30	181.3	179.2	178.0	-44.00
31	181.2	178.6	177.0	-42.43
32	181.3	178.1	176.9	-42.01
33	180.8	177.9	176.5	-41.33
34	180.7	177.3	176.1	-40.44
35	179.2	176.7	175.3	-38.86
36	179.5	176.9	174.7	-38.26

Table 2: Inverness PSR PD results – corrected for VPD

4.1.22. Table 2 confirms that the Cloiche Wind Farm turbines are highly unlikely to be detected by Inverness PSR.

4.2. Lossiemouth Radar

4.2.1. At its closest point the Proposed Development area is 92km from Lossiemouth Radar.

4.2.2. The magenta shading in Figure 10 illustrates the RLoS coverage from Lossiemouth Radar to turbines with a blade tip height of 149.9m AGL.

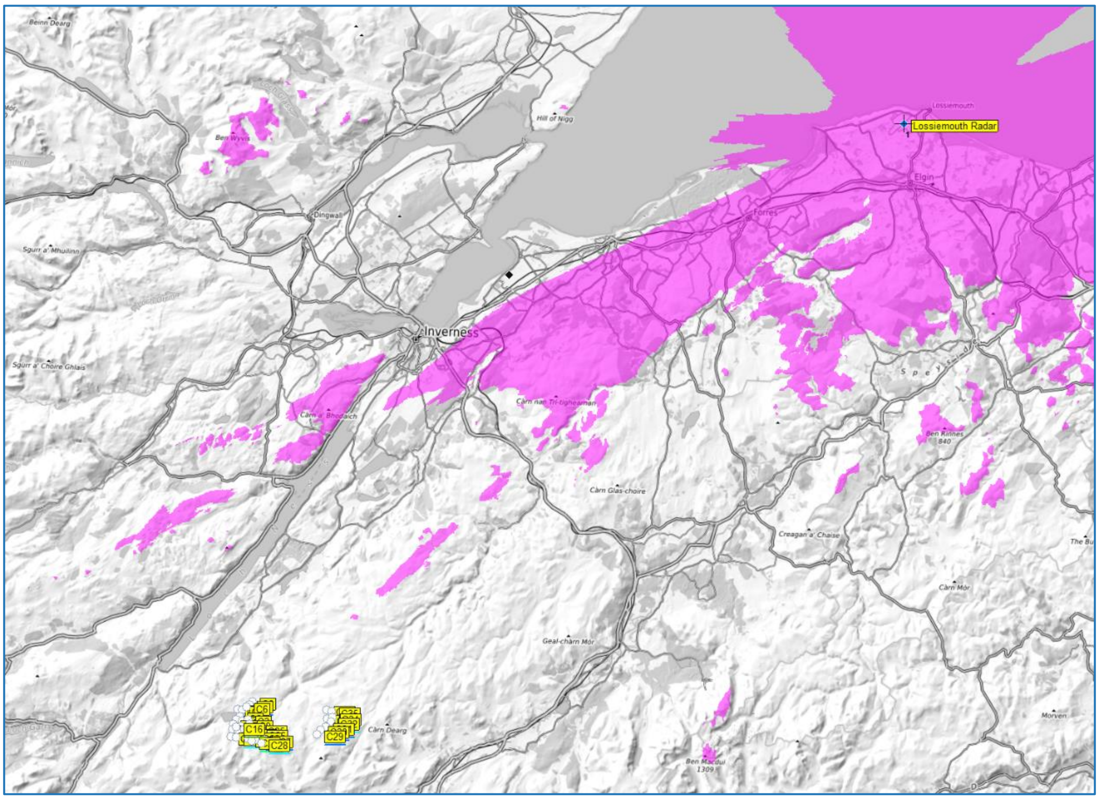

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Figure 10: Lossiemouth Radar RLoS to 149.9m AGL

4.2.3. RLoS does not exist between Lossiemouth Radar and any of the turbines in the finalised layout.

4.3. NERL PSRs

4.3.1. The NERL PSRs at Allanshill, Perwinnes and Tiree are 145km, 136km and 162km respectively from the Proposed Development.

4.3.2. The brown shading in Figure 11 illustrates the RLoS coverage from these NERL PSRs to turbines with a blade tip height of 149.9m AGL and shows that RLoS does not exist to any of the turbines in the finalised layout.

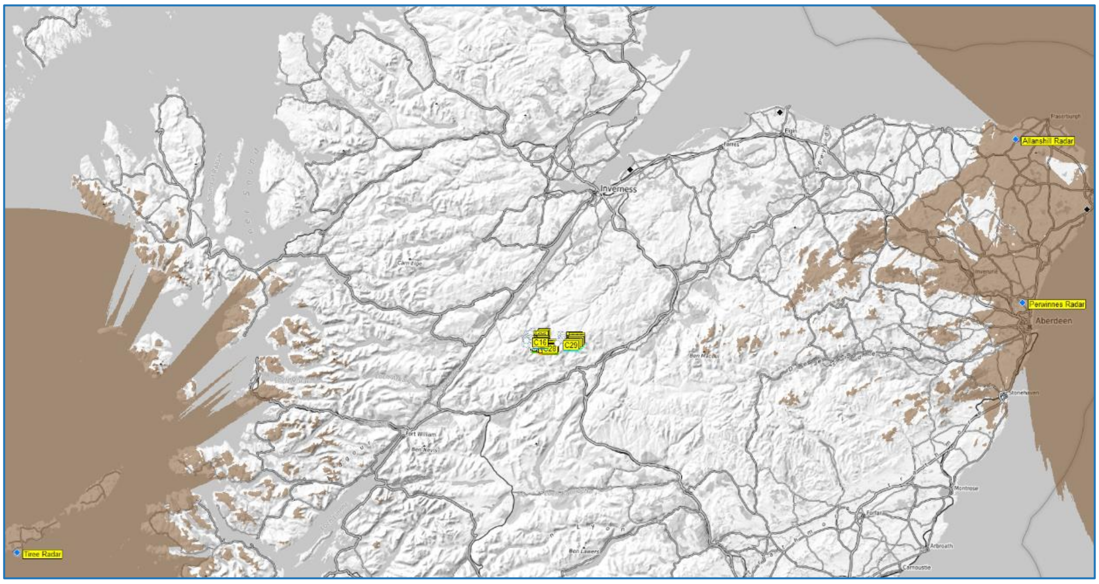

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Figure 11: NERL PSRs RLoS to 149.9m AGL

4.4. MoD AD Radars

4.4.1. The MoD AD Radars at Benbecula and Buchan are 185km and 159km respectively from the Proposed Development.

4.4.2. The brown shading in Figure 12 illustrates the RLoS coverage from these AD Radars to turbines with a blade tip height of 149.9m AGL and shows that RLoS does not exist to any of the turbines in the finalised layout.

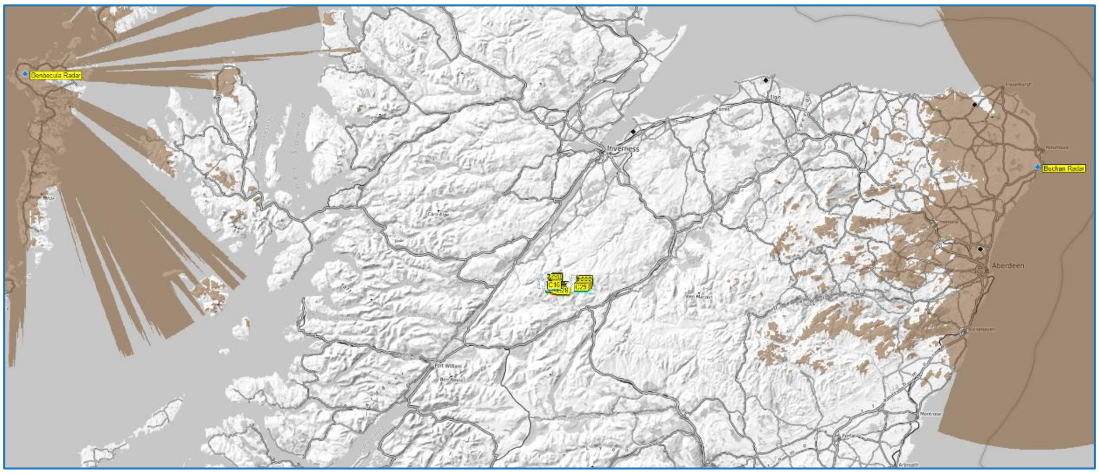

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Figure 12: MoD AD Radars RLoS to 149.9m AGL

5. Airspace

5.1. Introduction

5.1.1. This assessment is a review of potential impacts to aviation in the designated areas of Cloiche Wind Farm. For the purpose of this assessment, a maximum tip height of 3,000ft Above Mean Sea Level (AMSL) for the wind turbines has been assumed. This is based on the highest turbine site ground elevation of 752m AOD plus the 149.9m tip height, converted to feet.

5.1.2. All information has been referenced from the UK Aeronautical Information Publication available online from source and is therefore the latest information available. Additional information was sourced from UK Civil Aviation Authority (CAA) publications (as appropriate).

5.1.3. The assessment does not draw any conclusions but merely identifies areas of potential impact.

5.2. Scope

5.2.1. The scope of the assessment includes Cloiche Wind Farm and the surrounding airspace relating to aviation, its use and potential impact. Each area is defined according to type of airspace, limitations and who the controlling authority is.

5.3. Existing Environment

5.3.1. Airspace, in aviation terms, is defined as in two elements. The differentiation is required due to varying air pressure and to ensure aircraft are flying according to the same point of reference.

5.3.2. The first element is as an altitude AMSL and designated in terms of feet. The barometric pressure used is typically a local pressure at the last point at which this pressure can be verified.

5.3.3. Above a certain altitude, the level at which an aircraft flies at is referred to as a Flight Level (FL) using a common international barometric pressure setting of 1013.2 hPa. The transition between flying at an altitude and a FL is defined as a Transition Layer consisting of a Transition Altitude and a Transition Level. The Transition Altitude will always be the lower point, and, in the UK, this is set at 3,000ft with the exception of some specified airspace. In this case the Transition Altitude is set at 3,000ft. Refer UK AIP ENR 1.7 Altimeter Setting Procedures. The table below defines each area, associated airspace and impact.

Airspace or Route	Use	Airspace Dimensions Upper Limit Lower Limit	Impact	Controlling Authority	Remarks
N560	Lower ATS Route	FL195 FL105	Nil	NERL	Class E + Transponder Mandatory Zone
Low Flying Area (LFA) 14	Daytime Low Flying	2,000ft AGL surface	Unknown	MoD	Class G
PinS 14E	Rotary Low Flying	500ft AGL surface	Unknown	MoD	Class G
Area 1A	Night-time Low Flying	2,000ft AGL surface	Unknown	MoD	Class G
Area 1BE	Night-time Low Flying	2,000ft AGL surface	Unknown	MoD	Class G
Area 1C	Night-time Low Flying	2,000ft AGL surface	Unknown	MoD	Class G

Table 3: Airspace Structures

5.4. Controlled Airspace

5.4.1. There are no Control Areas or Control Zones impacted by Cloiche Wind Farm. The airspace surrounding Cloiche Wind Farm, excluding those defined in this paper are classified as Class G (uncontrolled airspace). This type of airspace does not normally have a controlling authority but may be subject to Visual Flight Rules (VFR) traffic. This is further explained in paragraph 5.5 (General Aviation Activity).

5.4.2. The only Lower ATS Route in the vicinity of the proposed turbine site is N560. N560 has a base level of FL105 (10,500ft based on 1013.2hPa) and this has a classification of Class E. The turbines therefore pose no conflict with this airspace.

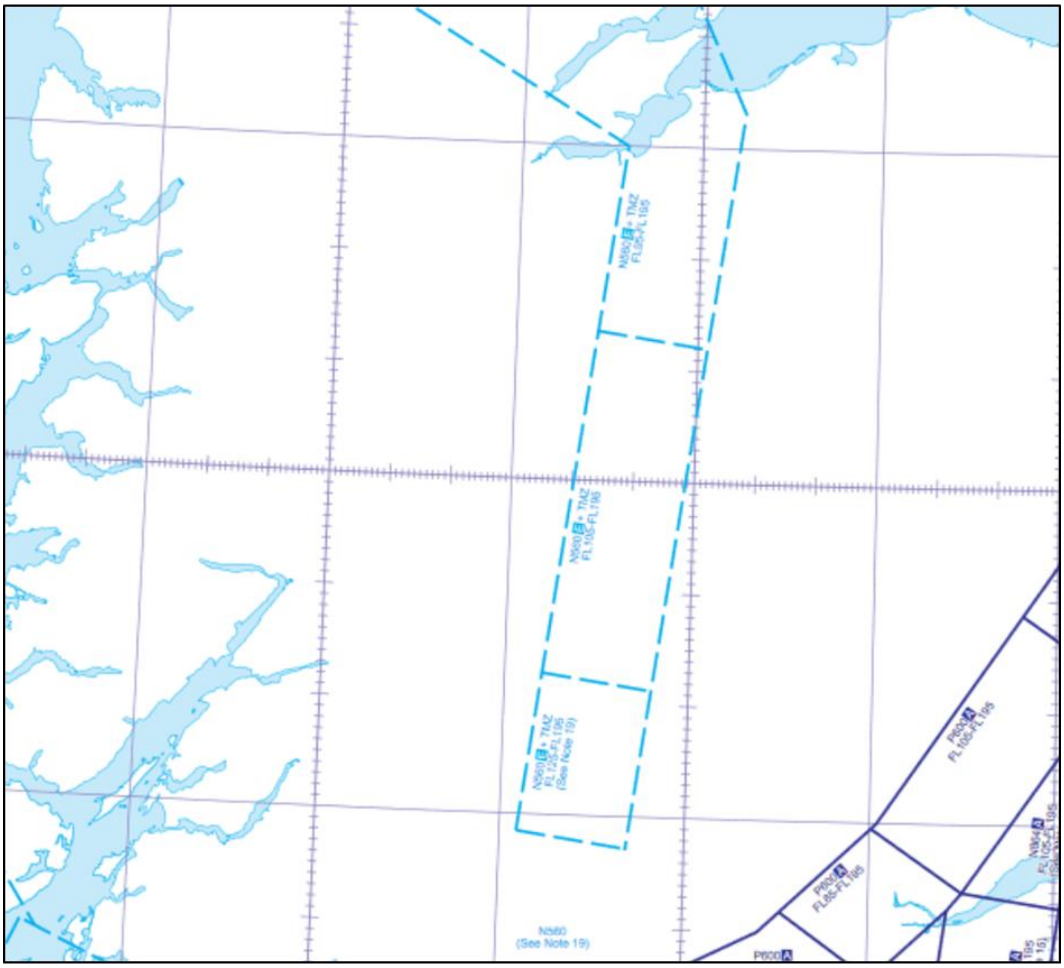


Figure 13: Lower ATS Route N560

5.5. General Aviation Activity

5.5.1. As the area is classified as a Class G airspace, i.e. not controlled by Air Traffic Control and not requiring specific procedures, there is a potential impact for general aviation flights to be in this area, (UK AIP ENR 1.4, 2,7 ATS Airspace Classification). There are specified 'rules of the air' that mitigate those aircraft capable of flying in the specified areas relating to visual metrological conditions which require aircraft flying below 3,000ft AMSL to have visibility of at least 5km and to be clear of cloud. Helicopters have a reduced visibility of 1,500m flight visibility if they fly at speeds below 140 knots. The culmination of these mitigations reduces the risk significantly.

5.5.2. There is a notified Area of Intense Gliding Activity to the east of the site (to the east of Feshiebridge) and it would therefore be prudent to engage with the gliding organisations in the region about the proposals.

5.5.3. The depiction of the windfarm, once approved, would need updating on the VFR 1:250,000 chart (Sheet 1) to reflect the increase in the area covered.

5.6. Military Low-Level Flying Areas

5.6.1. Low Flying Area (LFA) 14 (Day) and Position-In-Space (PinS) 14E (used by Rotary Wing Aircraft) are the defined Low-Level Flying areas that surround the proposed Cloiche Wind Farm site. There are also several night-time Low-Level Flying Areas affected. Low Flying is conducted by fixed-wing aircraft below 2,000ft AGL and below 500ft AGL by rotary-wing aircraft. The greatest concentration is however between 250ft and 500ft AGL. Engagement with the MoD will be expected and if approved, the turbines will need to be lit in accordance with MoD Policy.

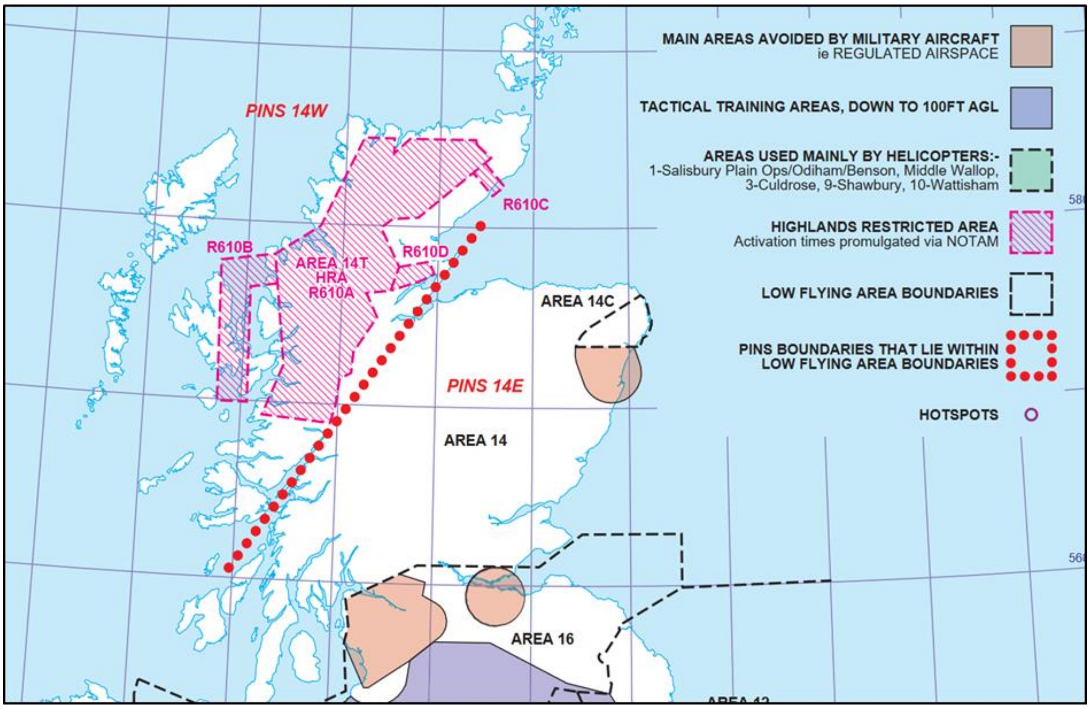


Figure 14: Low-Level Flying Areas (Day)

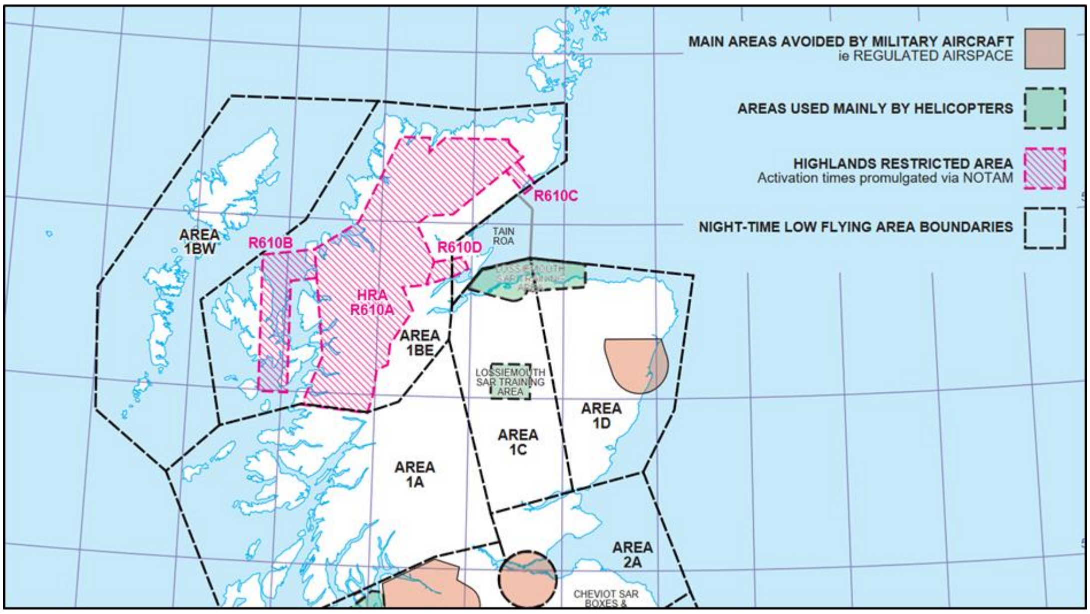


Figure 15: Low-Level Flying Areas (Night)

5.6.2. The Highland Restricted Area (R610A) lies to the North West and is not impacted by the Proposed Development.

5.7. Airspace Summary

5.7.1. The area surrounding Cloiche Wind Farm is clear of any controlled airspace and any significant aviation activity apart from LFA 14 and the Area of Intense Gliding Activity to the east in the vicinity of Feshiebridge. On the assumption that the wind turbines do not exceed a height of more than 3,000ft AMSL the only potential impacts are those described above. The airspace surrounding Cloiche is depicted at Figure 16 below.

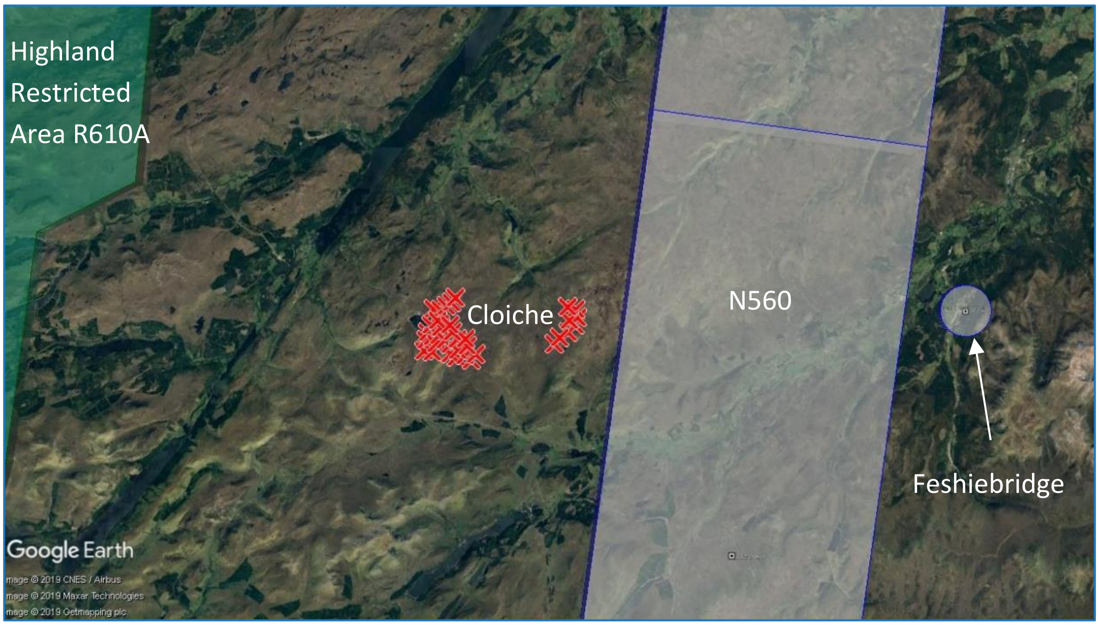


Image © 2020 Google, 2019 CNES/Airbus, Maxar Technologies & Getmapping plc

Figure 16: Google Earth Screengrab Cloiche Windfarm with N560 depicted

5.7.2. It is anticipated that the MoD, and other aviation stakeholders as required, would be consulted on the Proposed Development during the determination period.

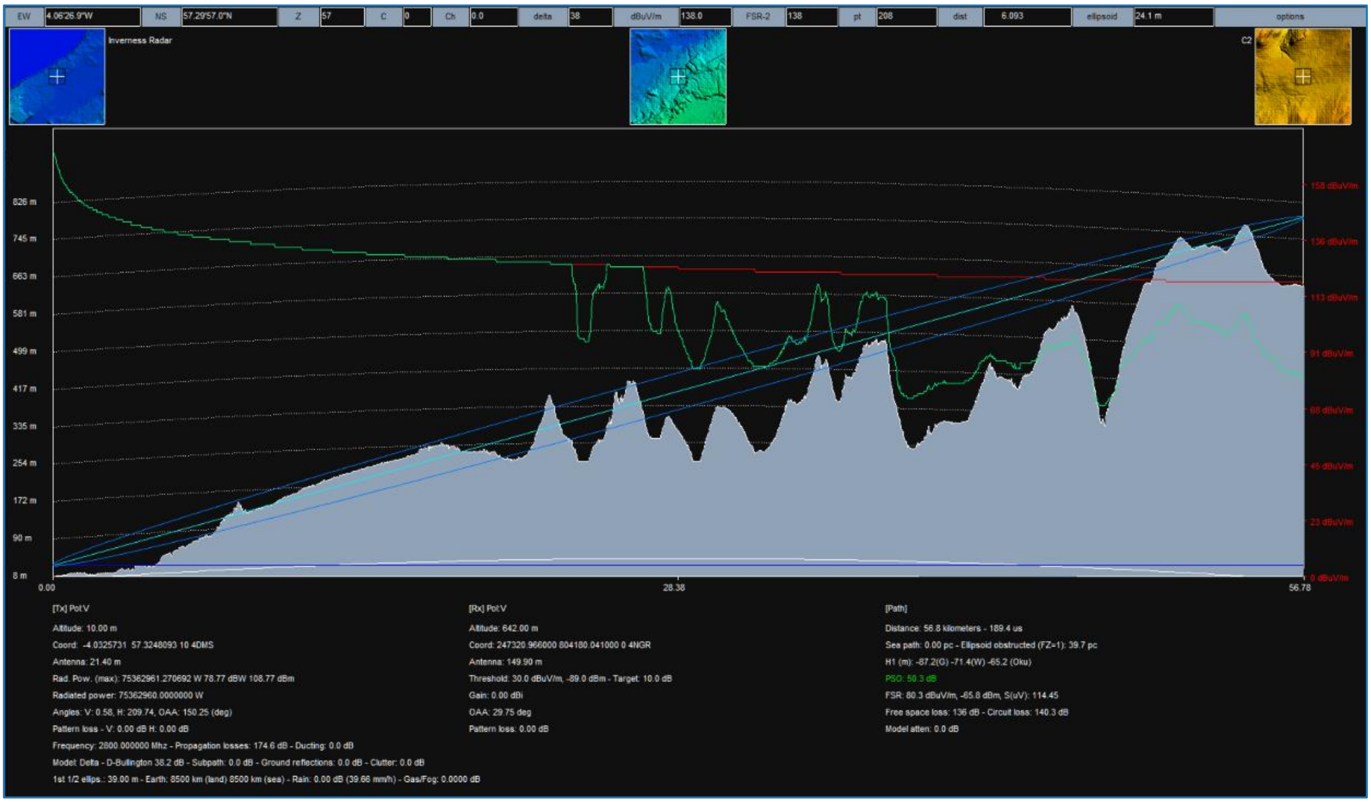
6. References

6.1. Civil Aviation Authority (CAA), (2020) CAP 032 – UK Aeronautical Information Publication (AIP), [Online], Available: https://www.aurora.nats.co.uk/htmlAIP/Publications/2020-01-30-AIRAC/html/index-en-GB.html [accessed 20 Feb. 2020].

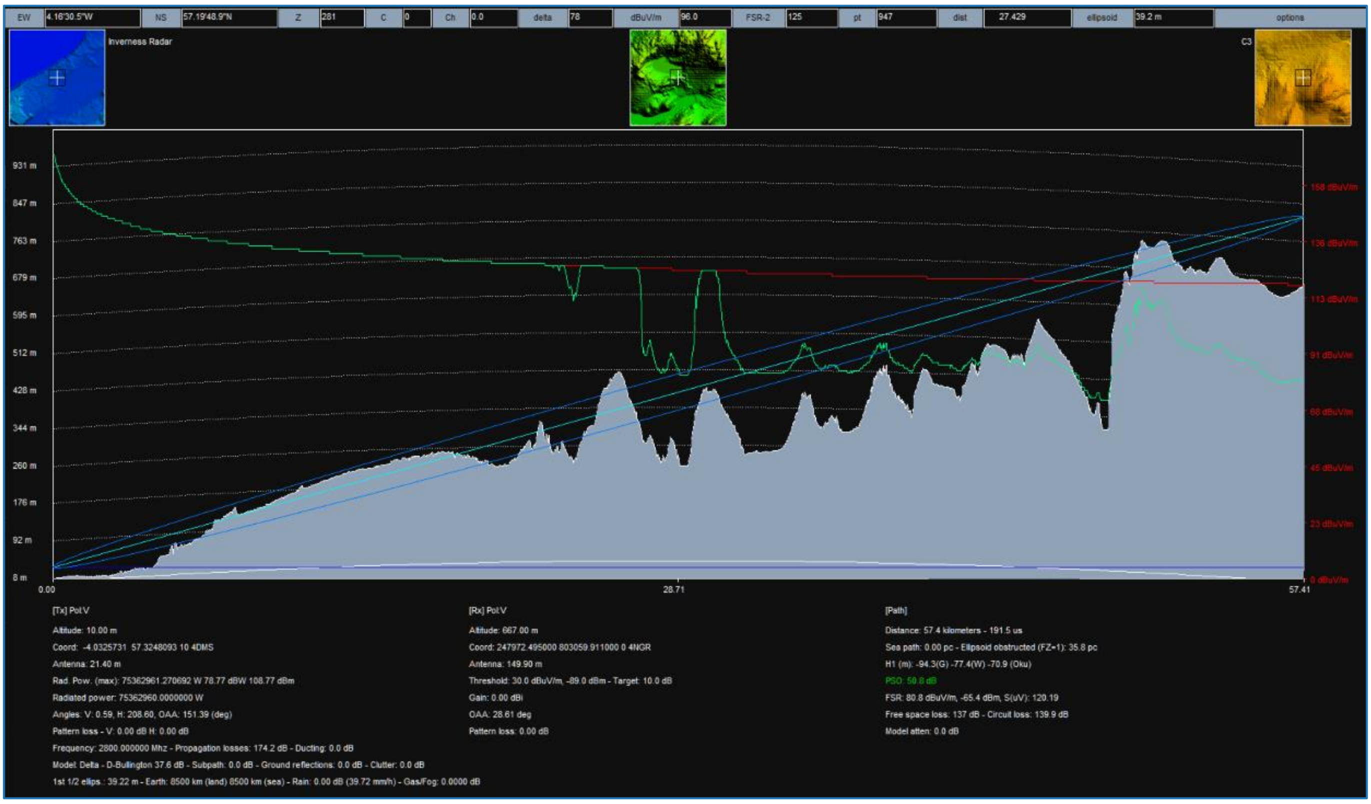
A. Annex A – Inverness Radar Path Profiles

A.1. Turbine C1

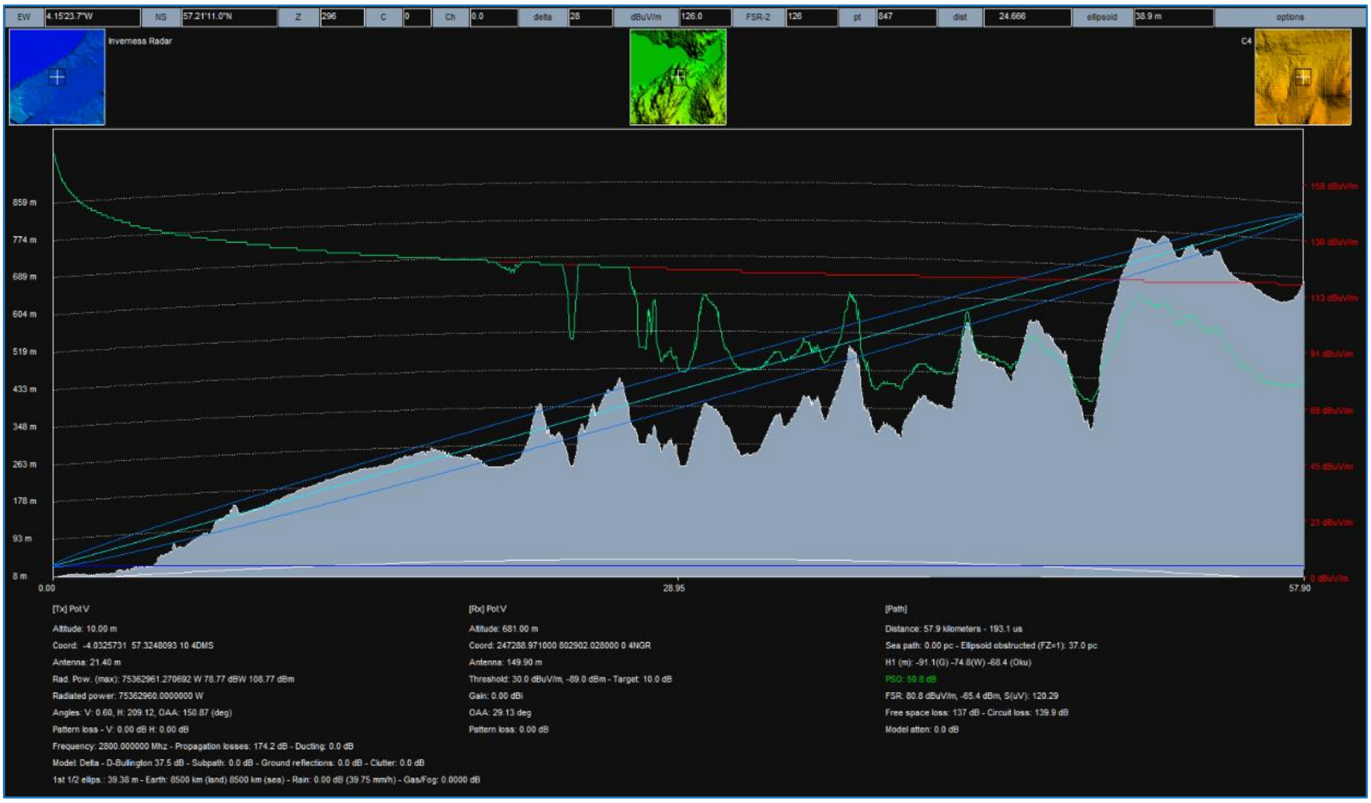
A.2. Turbine C2



A.3. Turbine C3



A.4. Turbine C4

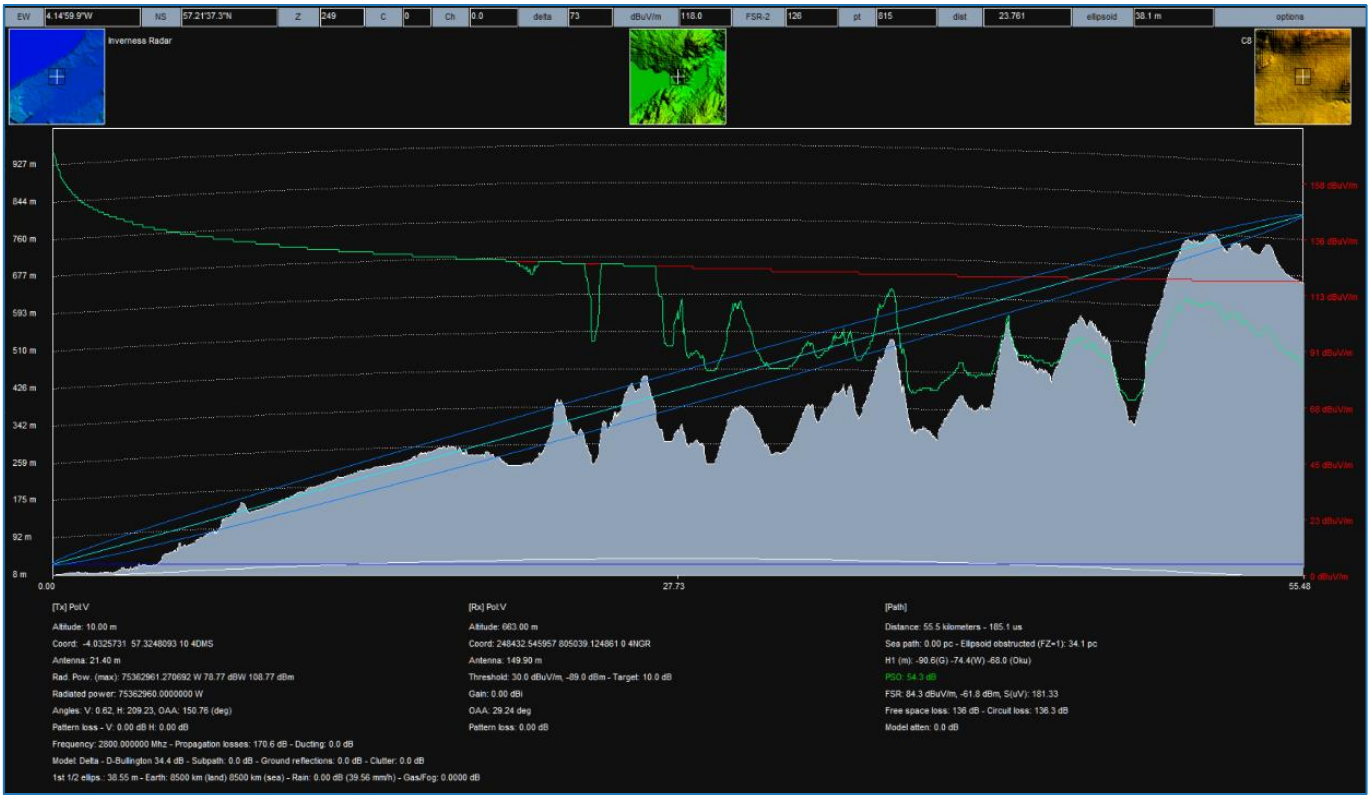


A.5. Turbine C5

A.6. Turbine C6

A.7. Turbine C7

A.8. Turbine C8



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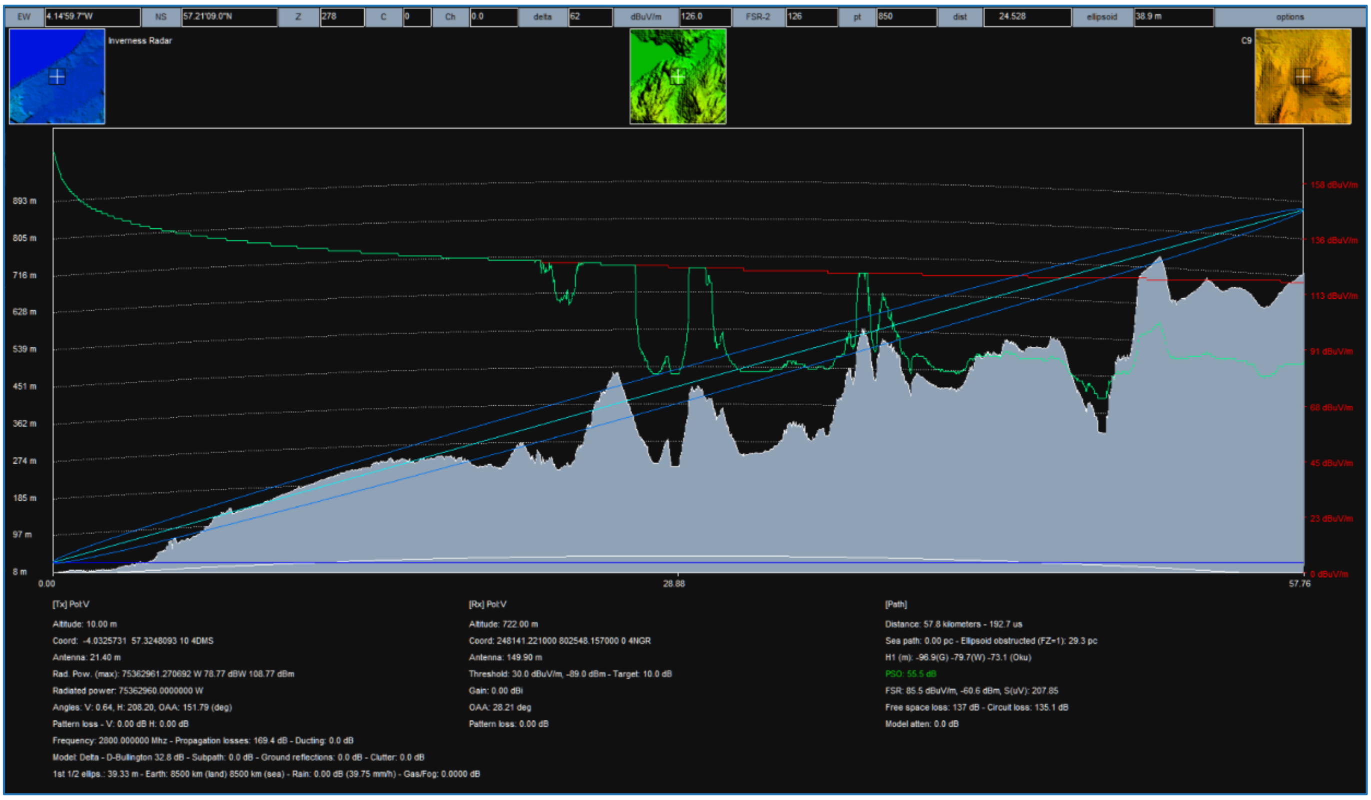

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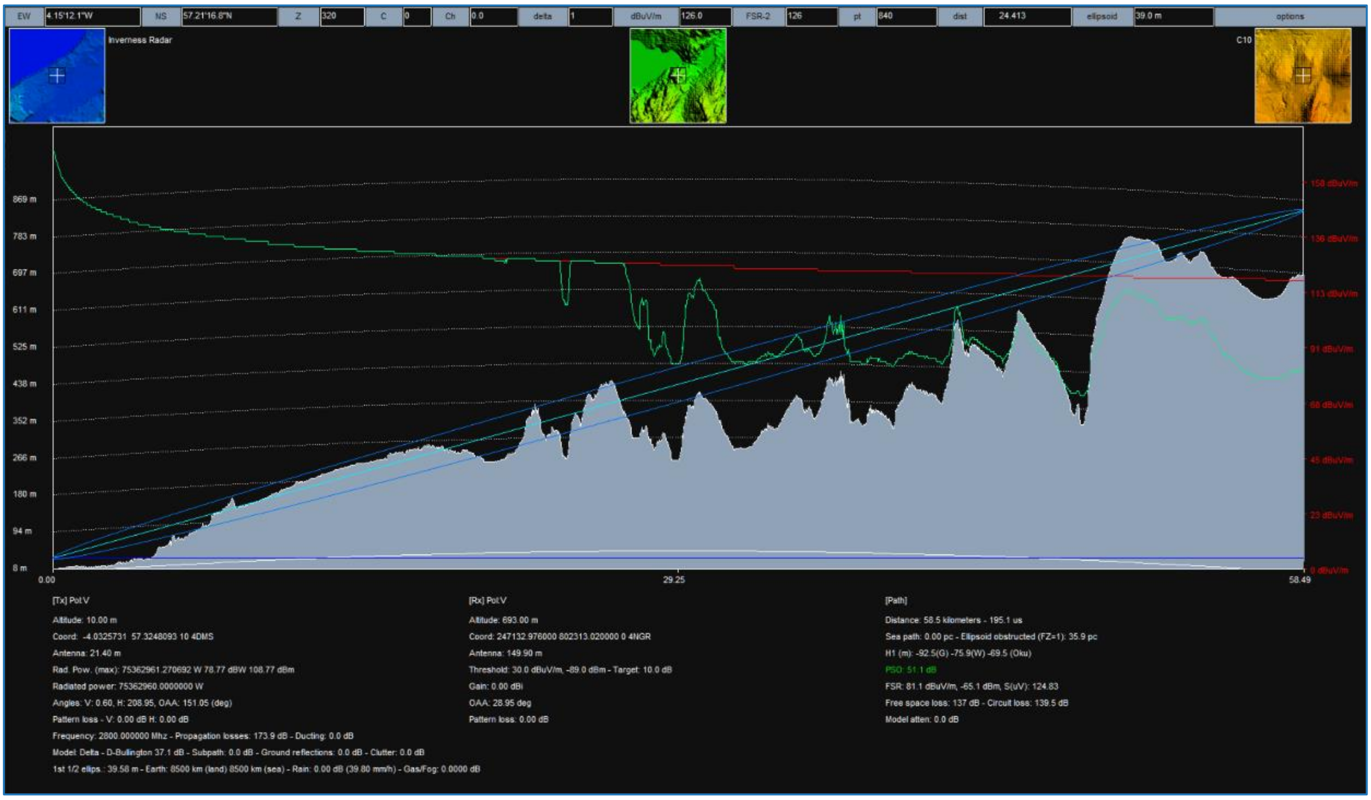

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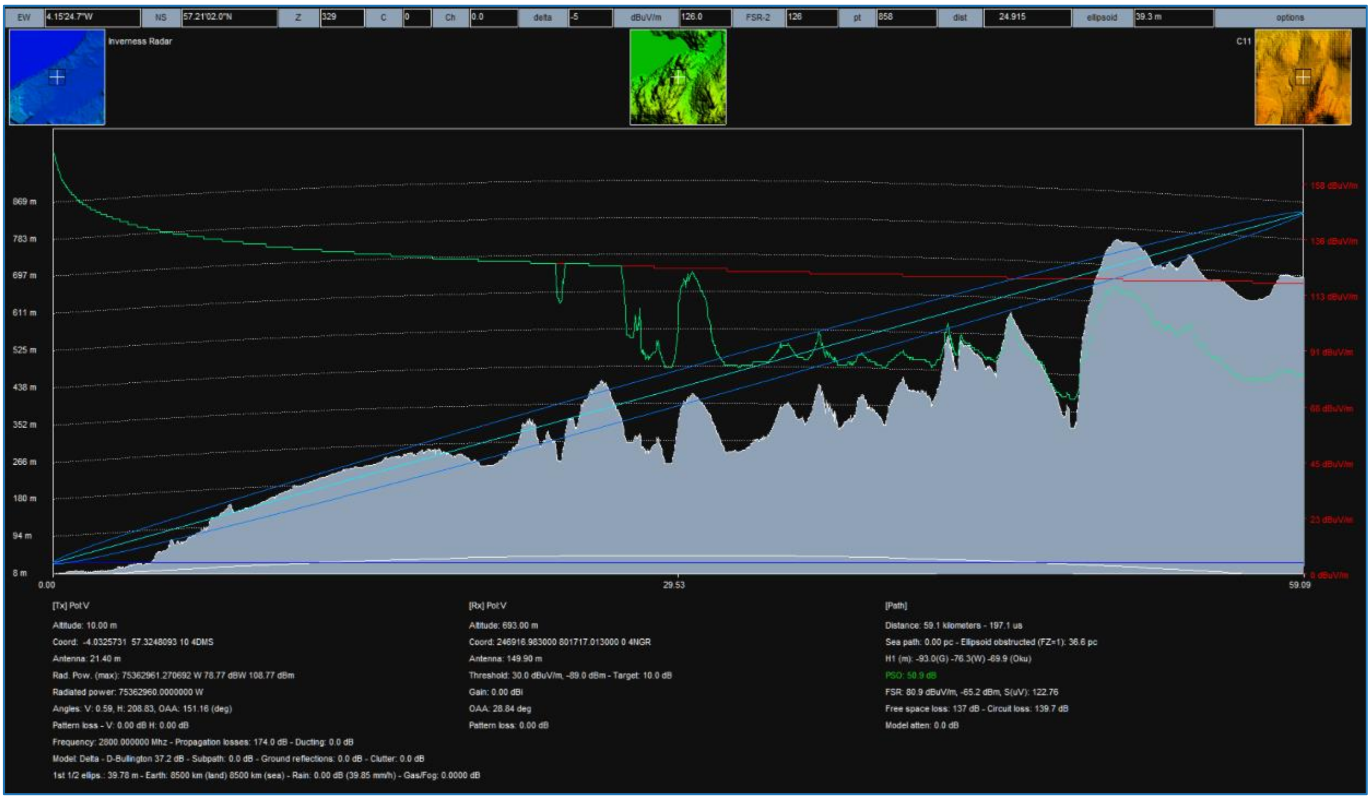

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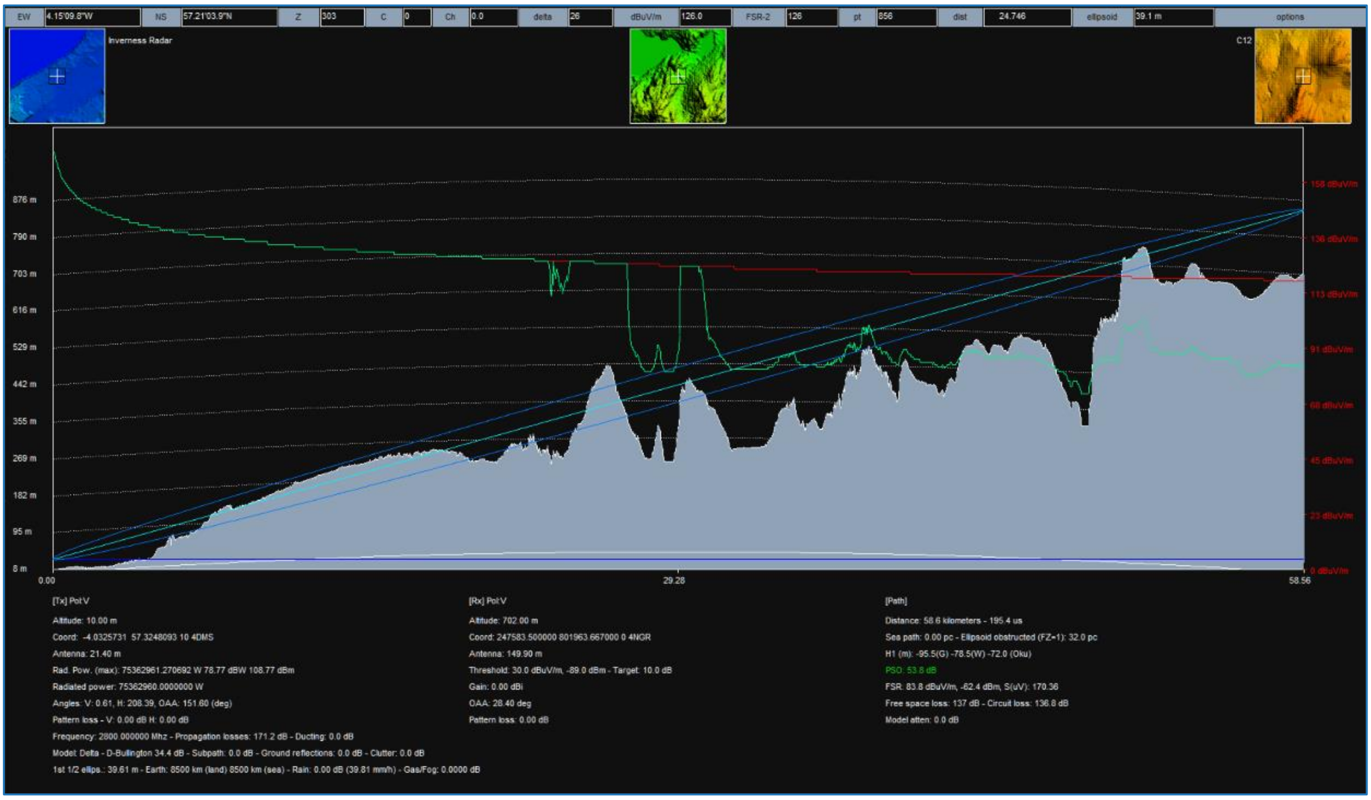

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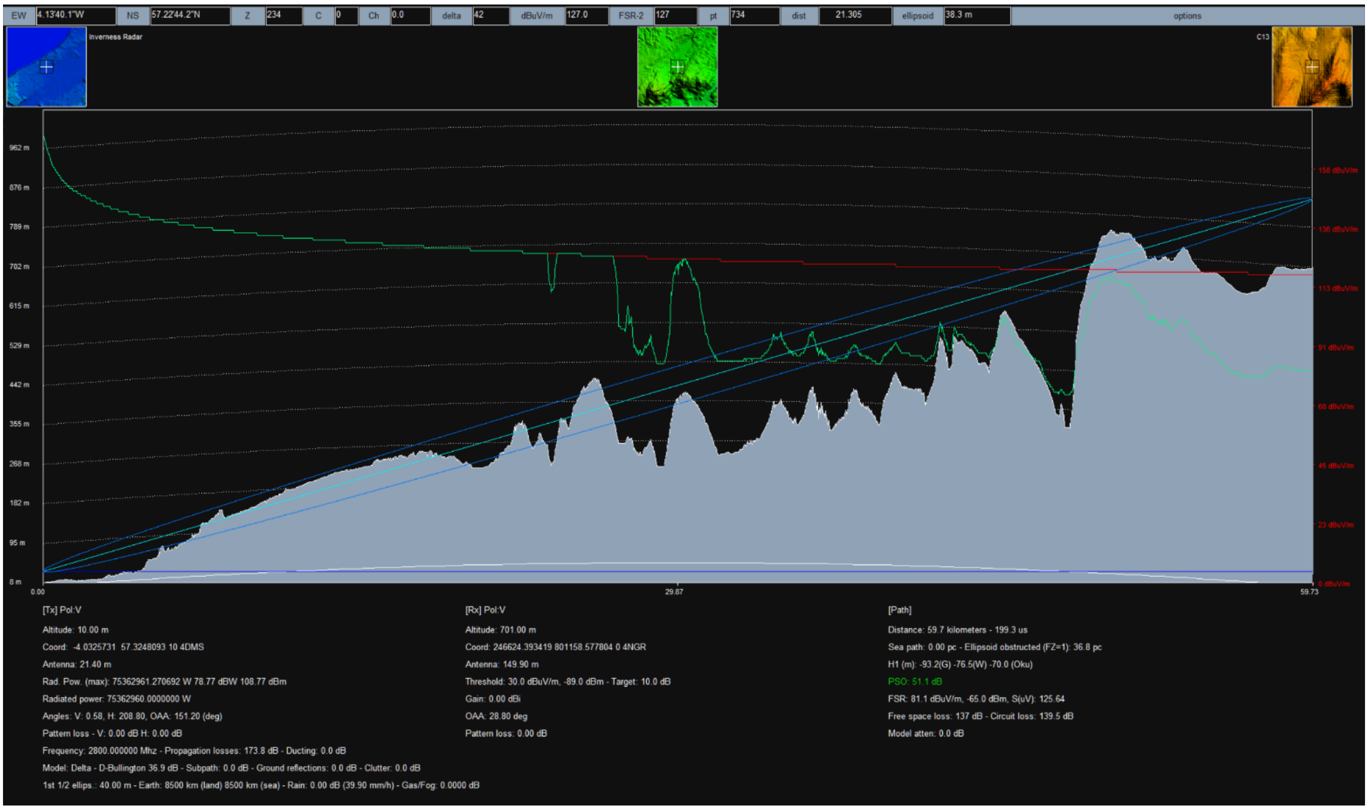


A.14. Turbine C14

A.15. Turbine C15

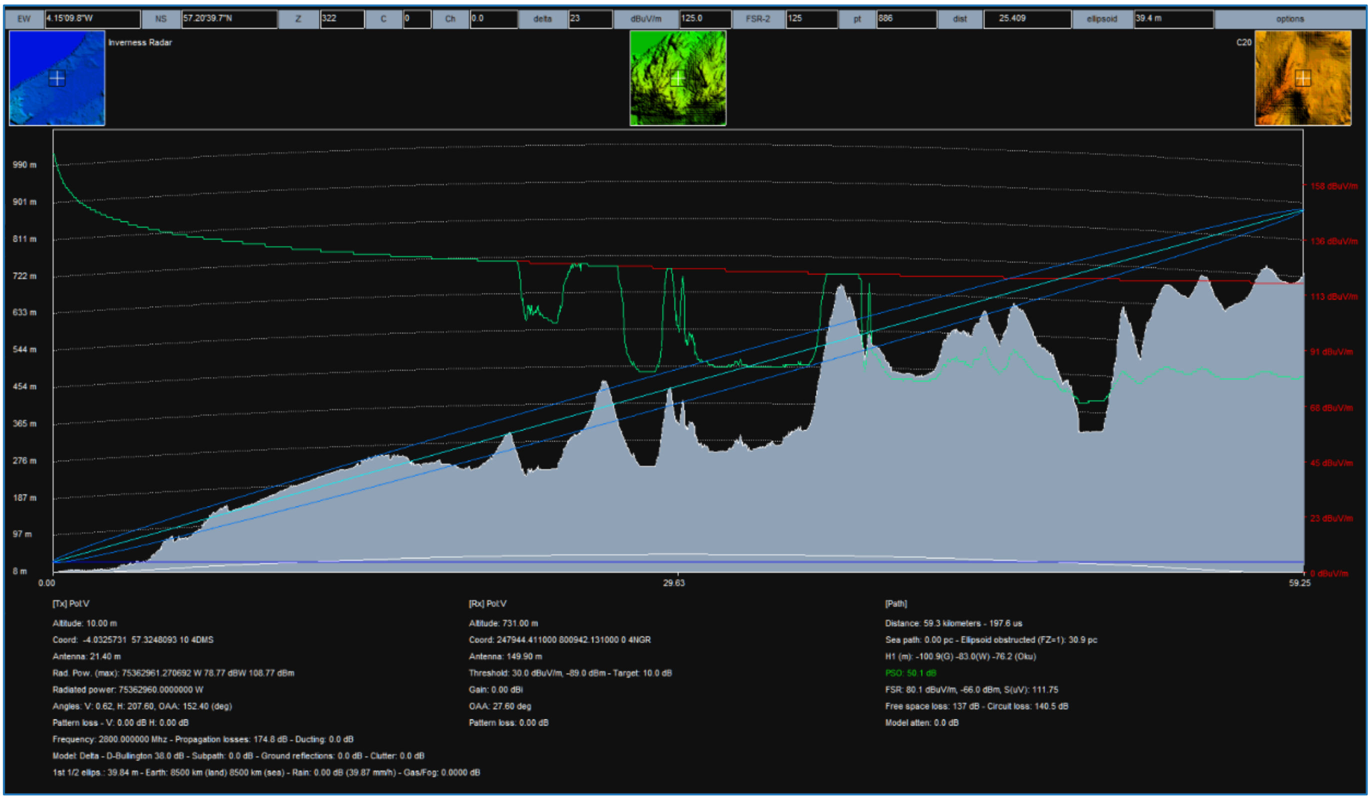
A.16. Turbine C16

A.17. Turbine C17

A.18. Turbine C18

A.19. Turbine C19

A.20. Turbine C20



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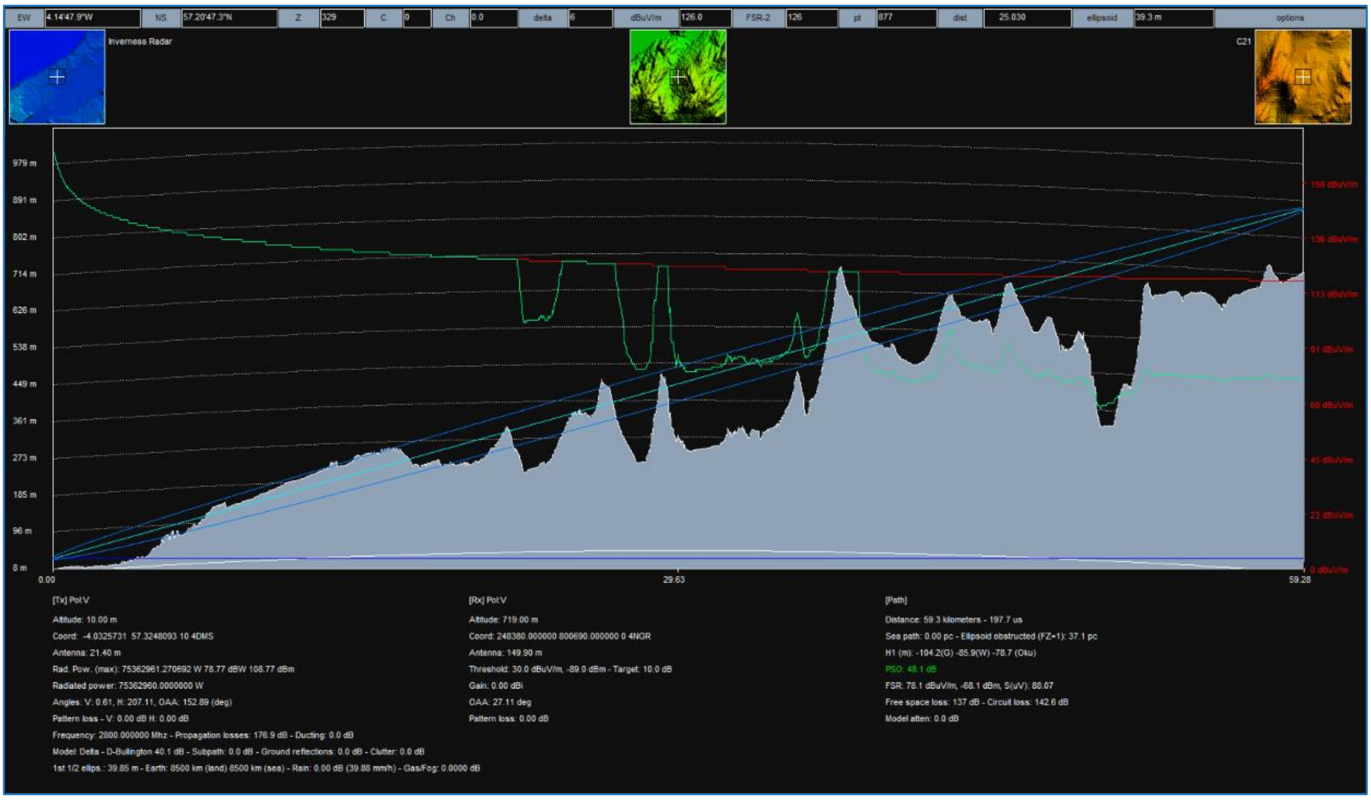

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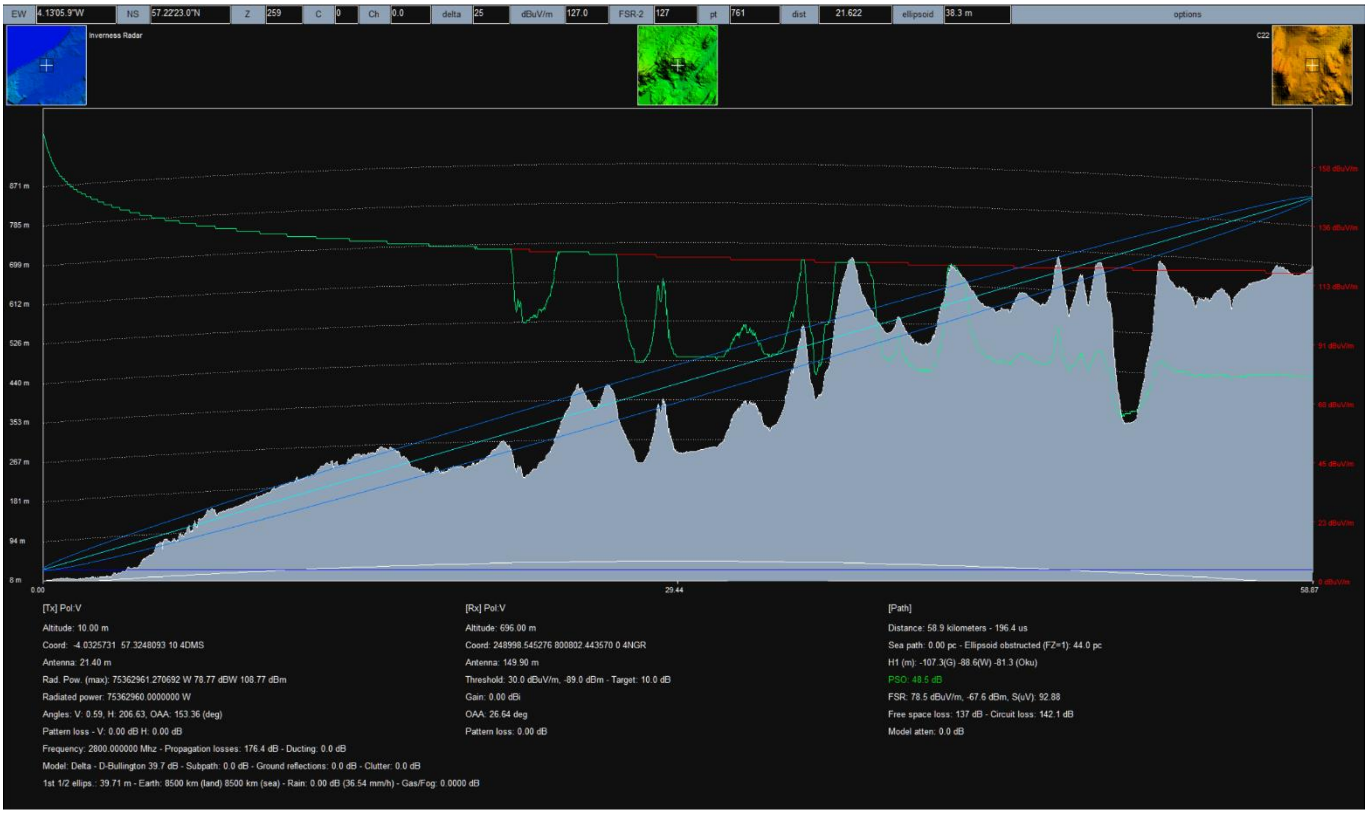

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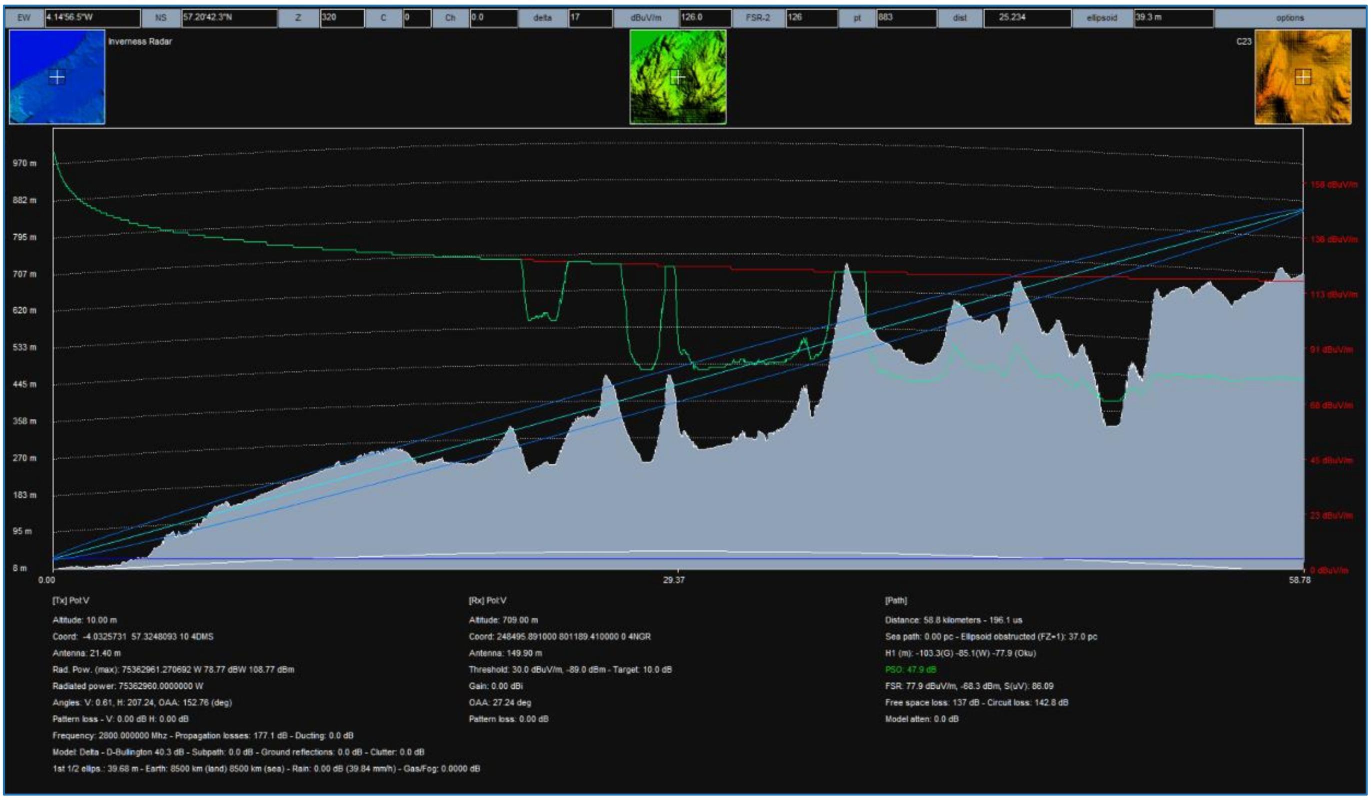

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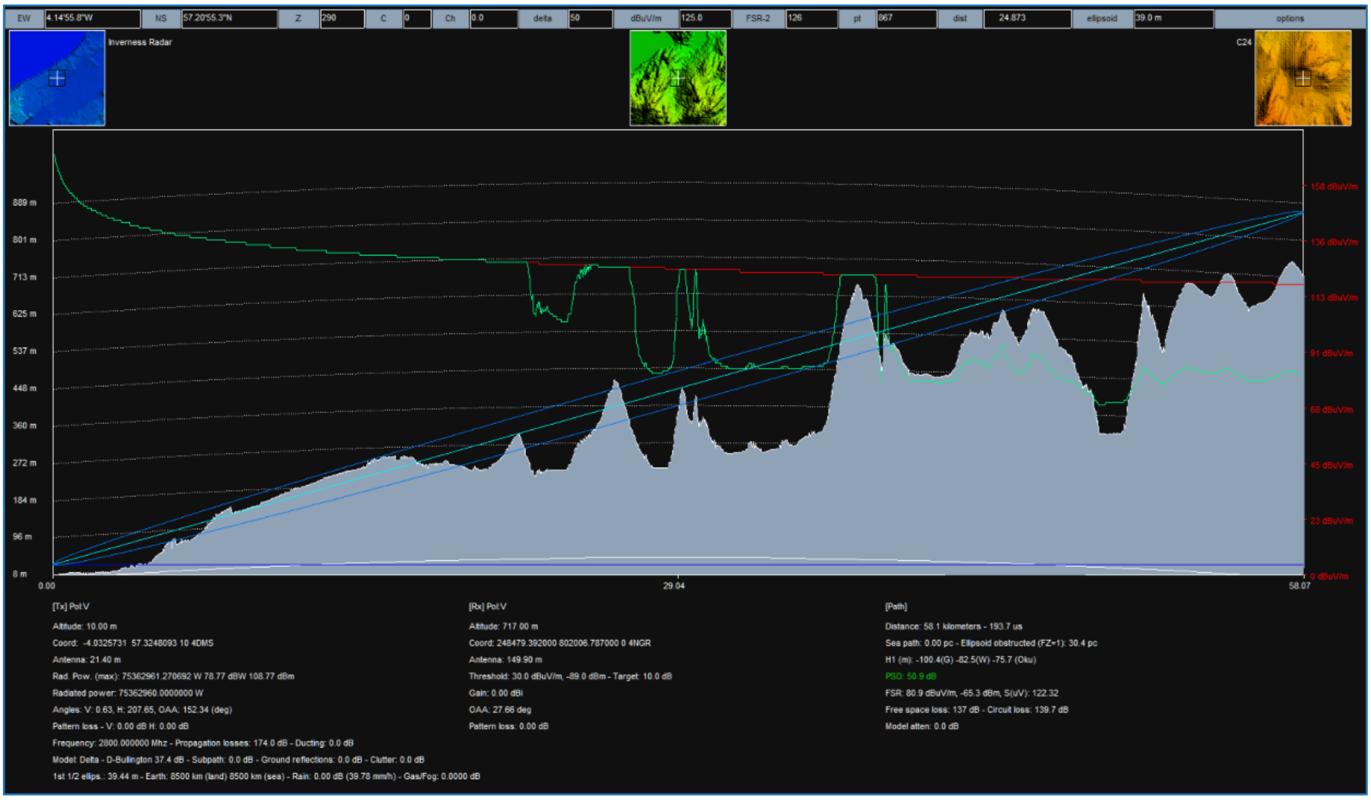

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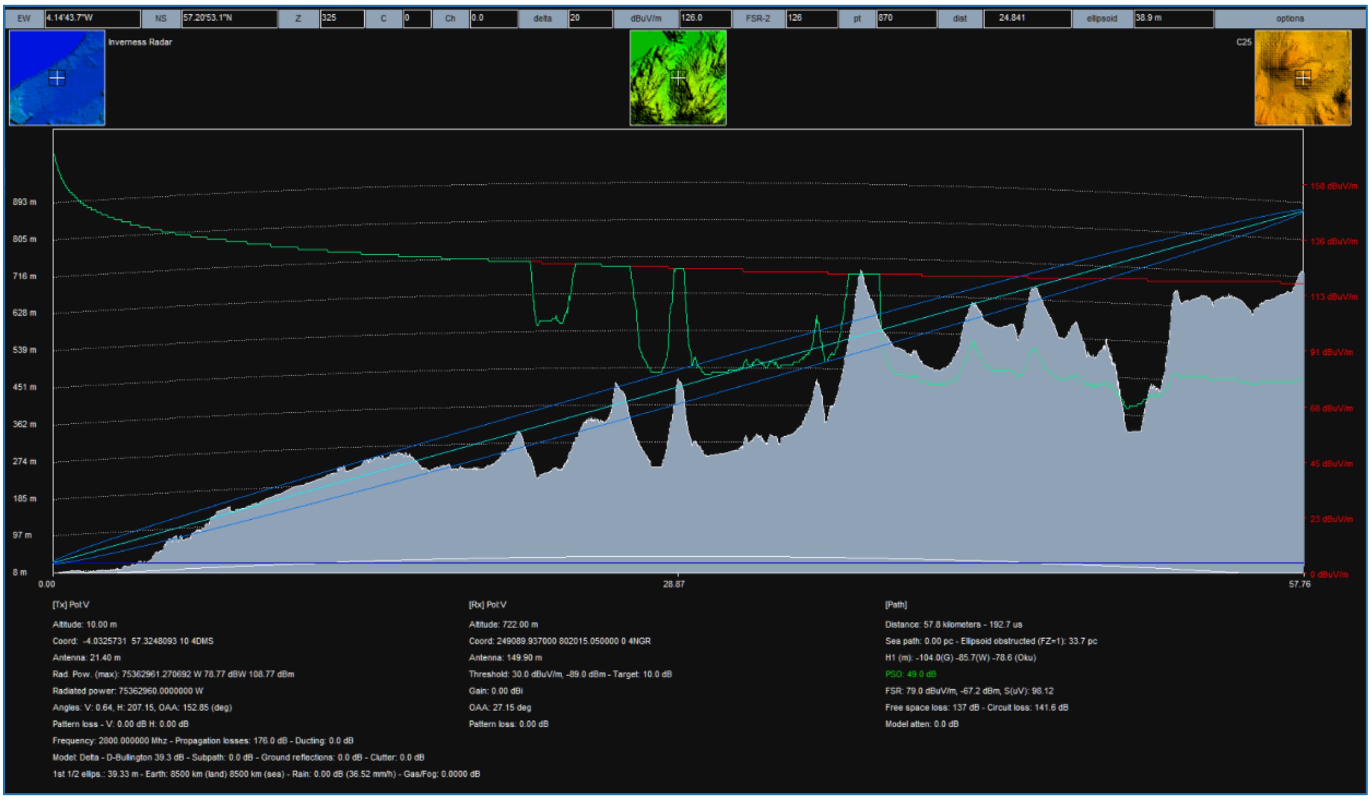

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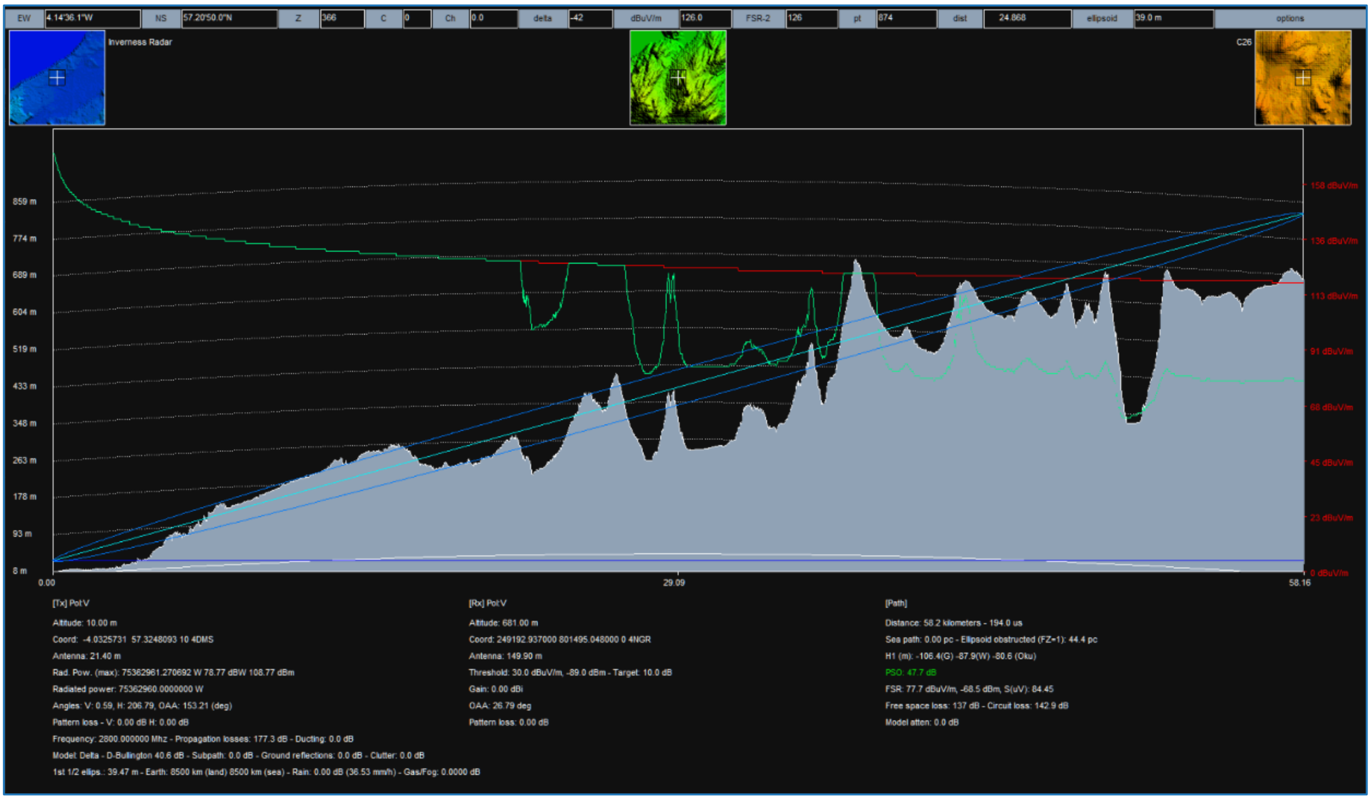

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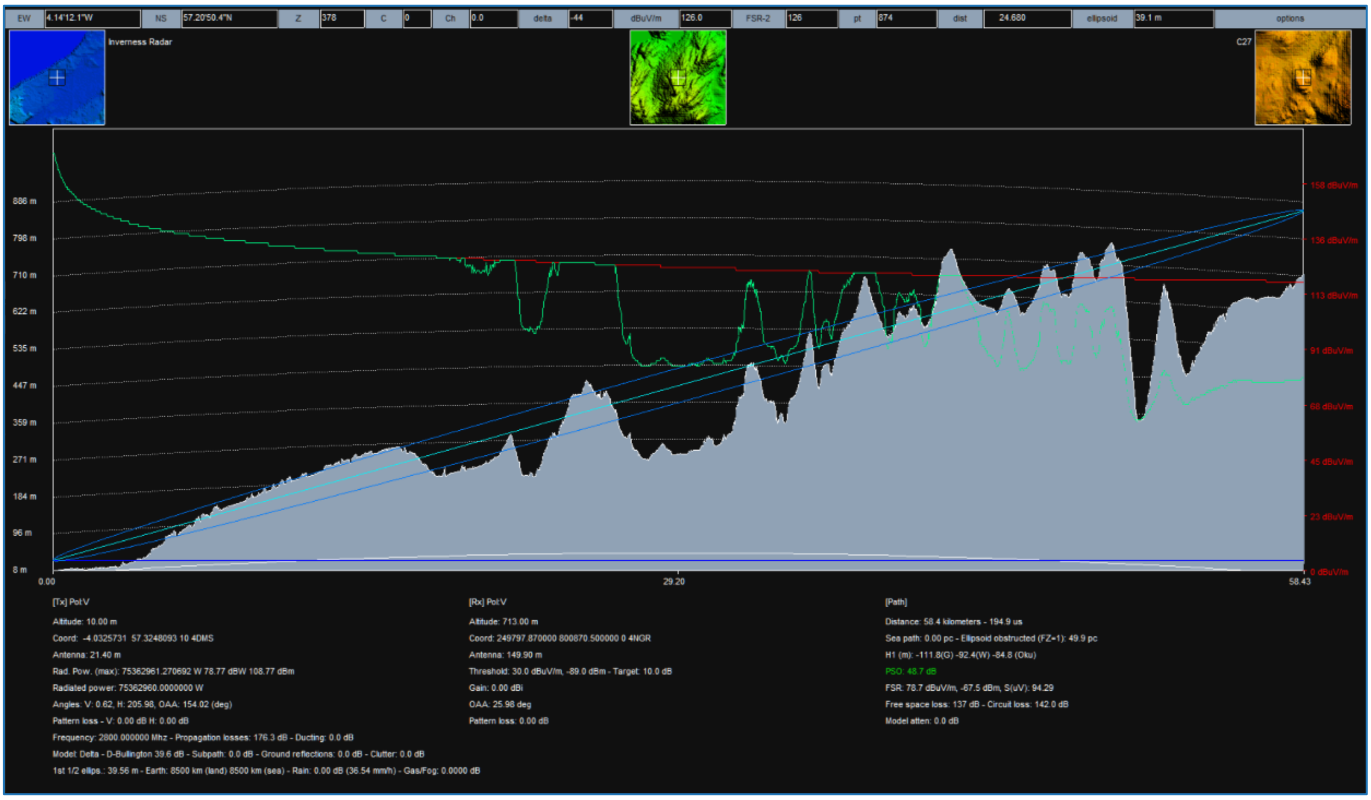

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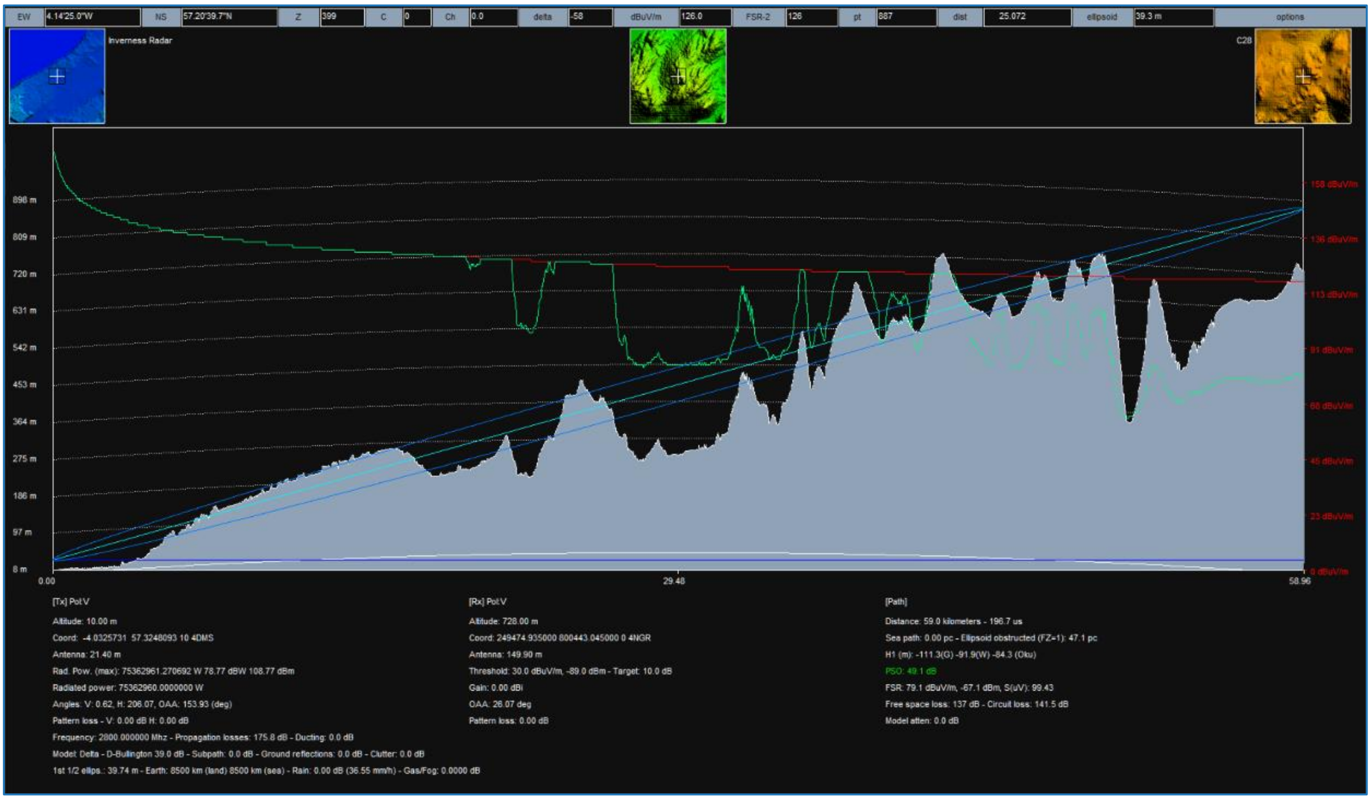

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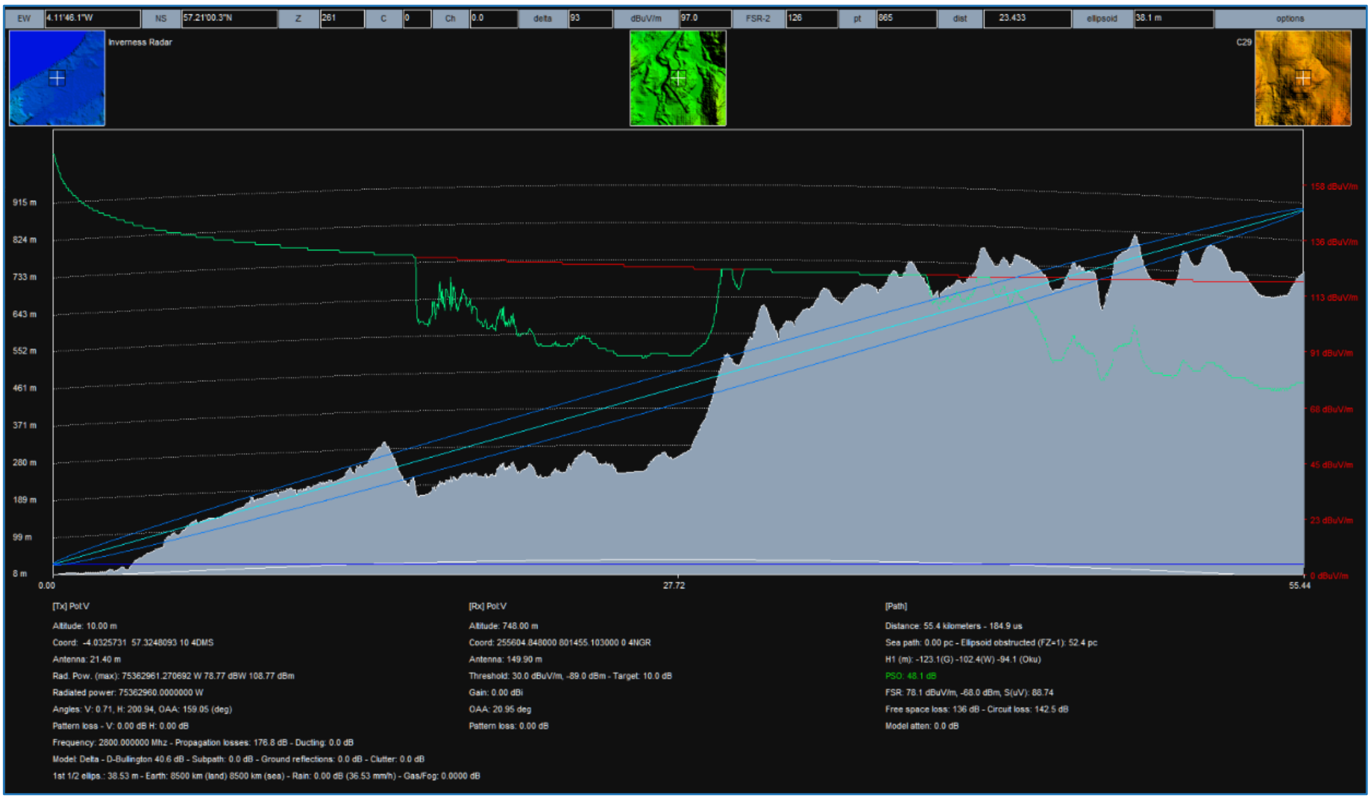

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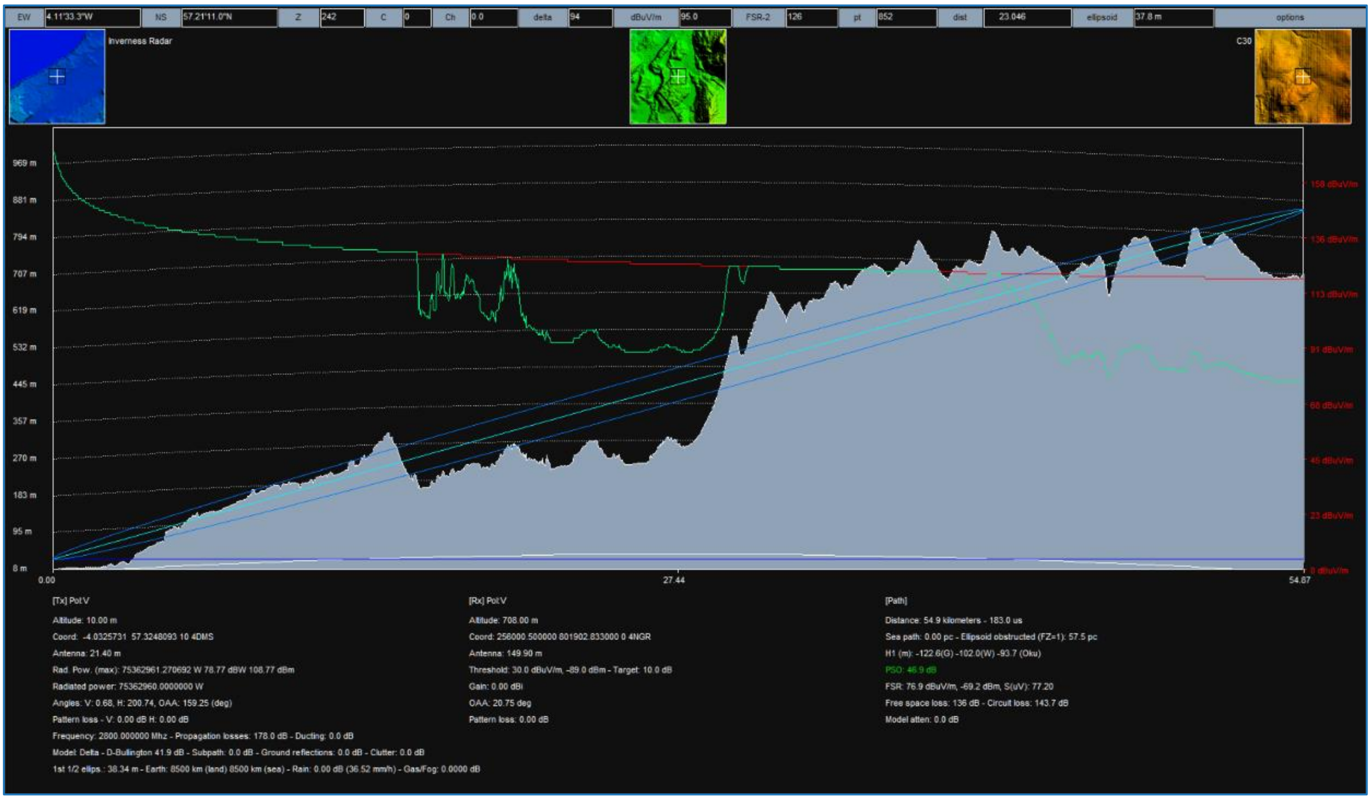
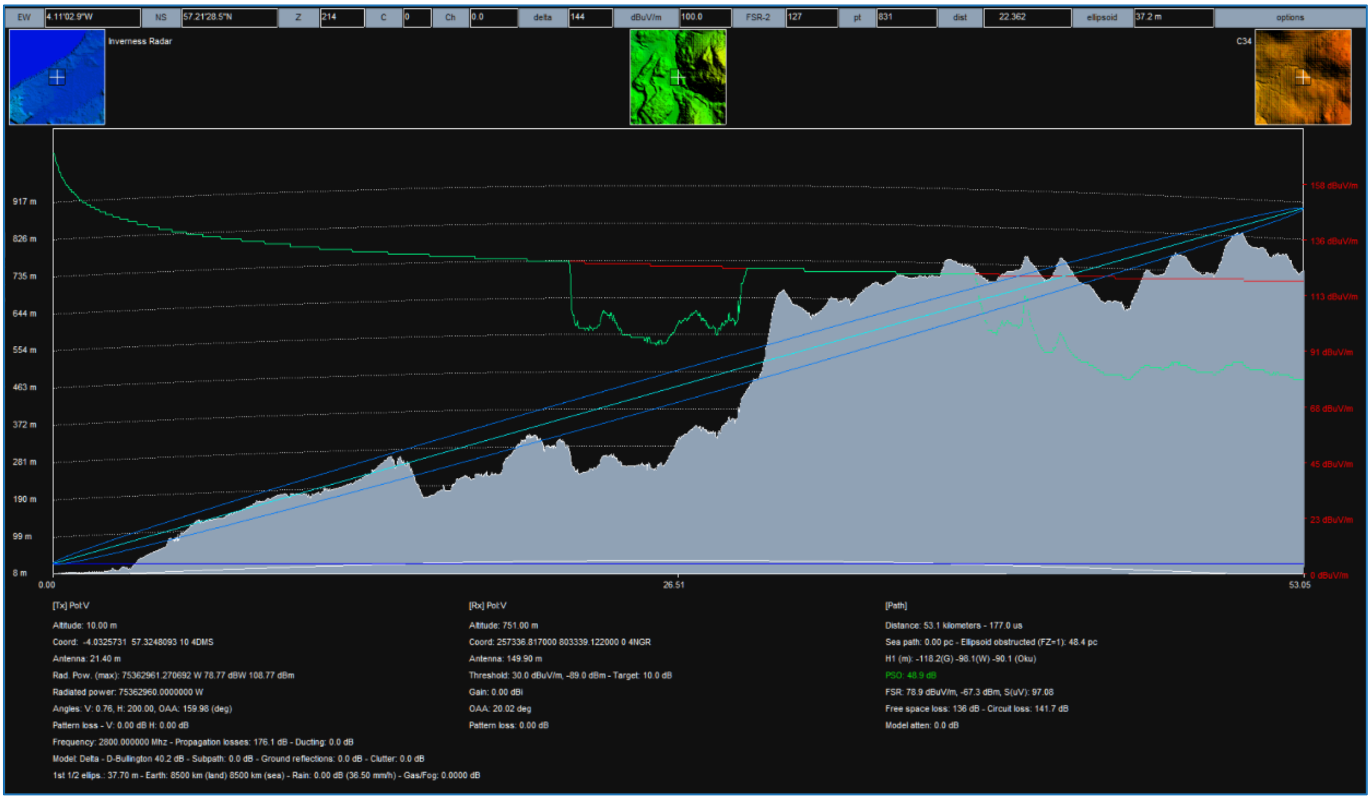


A.31. Turbine C31

A.32. Turbine C32

A.33. Turbine C33

A.34. Turbine C34



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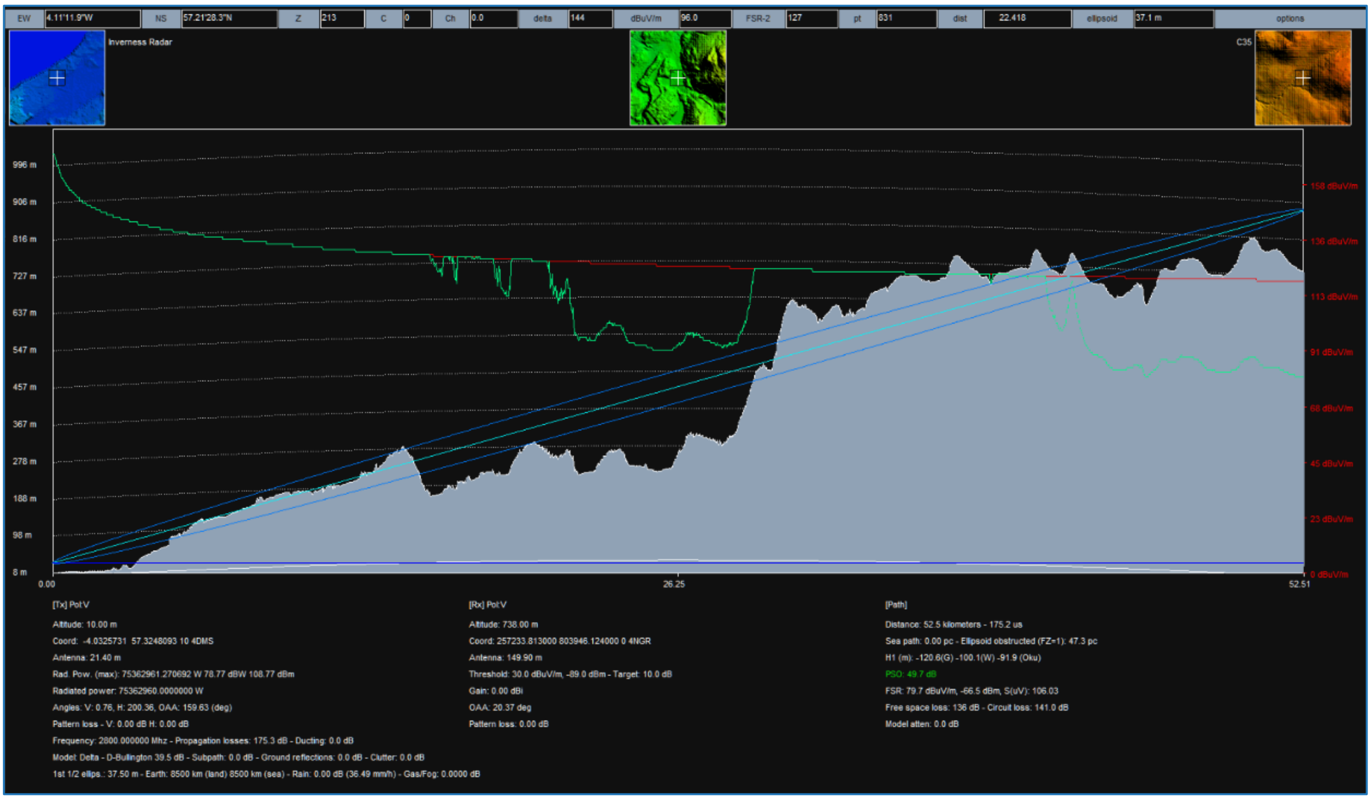

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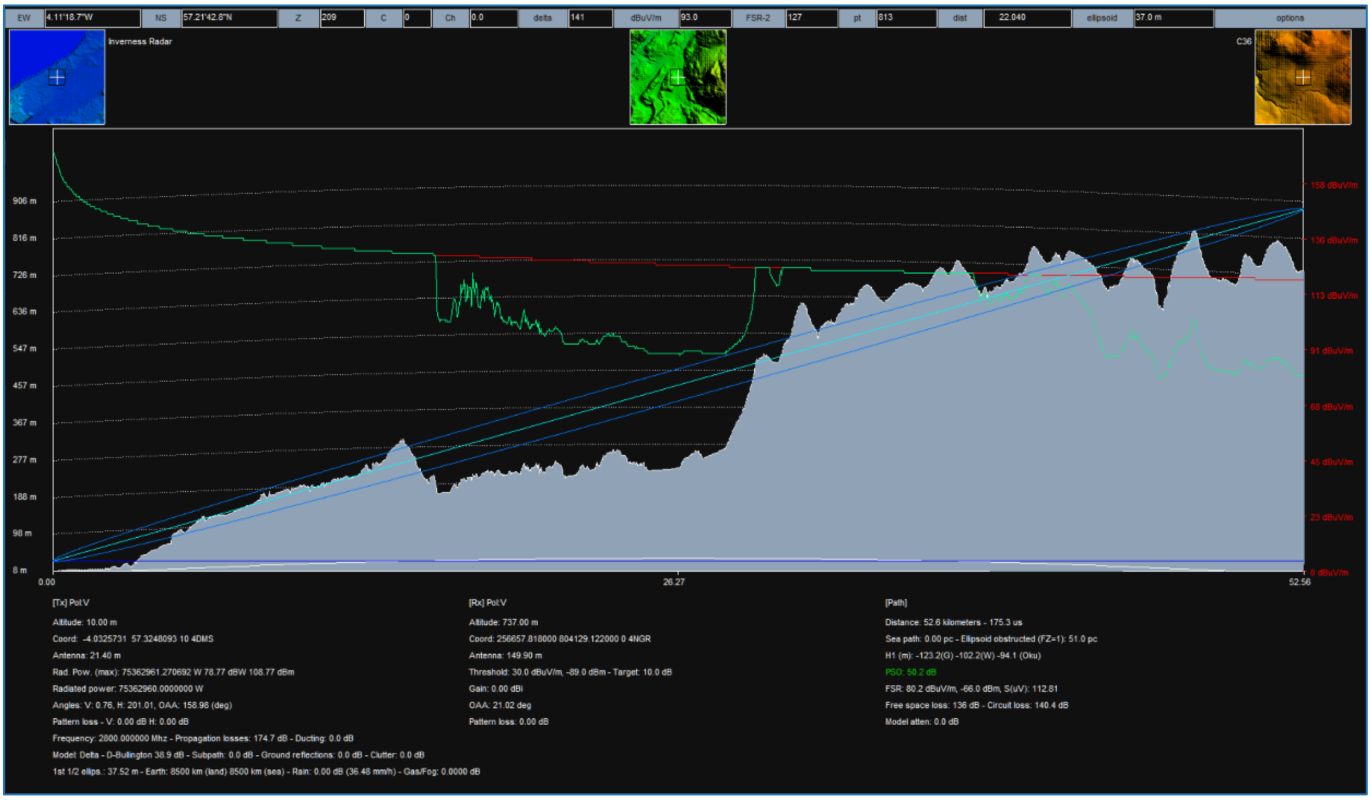

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