Technical Appendix 15.2

Aviation Impact Assessment

www.scottishpowerrenewables.com

SCOTTISHPOWER RENEWABLES

CYRRUS

Aviation Impact Assessment

Euchanhead Renewable Energy Development

29 September 2020

CL-5487-RPT-003 V4.1

www.cyrrus.co.uk

info@cyrrus.co.uk

Executive Summary

Cyrrus Limited was commissioned by ScottishPower Renewables (SPR) to undertake an aviation desk study for the proposed Euchanhead Renewable Energy Development site, in Dumfries and Galloway, approximately 9.8km south west of Sanquhar, as measured to the nearest turbine. The proposed Development is anticipated to comprise up to 21 turbines with a maximum blade tip height of 230m.

Of the aviation stakeholders consulted, NATS (en Route) [NERL] and Glasgow Prestwick Airport (GPA) have indicated that they will object to the proposal due to the turbines being visible to one or more of their Primary Surveillance Radars (PSRs).

Initial modelling of the S511 and Terma PSRs at GPA shows that 14 of the 21 proposed turbines are in Radar Line of Sight (RLoS) of these radars. Probability of Detection (PD) analysis indicates that of the 7 turbines that are not in RLoS of the S511 PSR, 6 are unlikely to be detected by the S511 radar. Of the same 7 turbines that are not in RLoS of the Terma PSR, PD analysis confirms that they are all unlikely to be detected by the Terma radar.

The GPA Terma PSR is an X band radar that can distinguish between unwanted returns from wind turbines and wanted returns from aircraft and as such is considered to be windfarm tolerant. The Terma radar can mitigate the effects of turbines by masking the areas around them and relying on inter-turbine tracking. Analysis of these blanked areas shows that aircraft transiting Euchanhead with a groundspeed of up to 250 knots may not be detected on two consecutive scans, however three consecutive non-detections are required before a track is dropped.

As an alternative to masking of turbines, when inter-turbine spacing is 500m or more, as is the case for Euchanhead, the Terma can automatically detect turbines and maintain internal tracks (that are not displayed to the controller) while simultaneously tracking airborne targets over the windfarm. In other words, the inherent processing capabilities of the GPA Terma should be able to mitigate the impact of the RLoS turbines without any further intervention and as a result, there should be no negative impact on the air traffic service (ATS) provided by GPA.

The GPA S511 PSR is a legacy planning radar that it is understood will be replaced by the Terma PSR as the GPA approach radar in due course.

Initial modelling of the NERL PSRs at Lowther Hill and Great Dun Fell shows that all 21 turbines are in RLoS of these radars. It can be assumed that these radars will detect all the Euchanhead turbines.

Potential infill mitigation could be provided by Cumbernauld PSR, which has minimum coverage of 3,500ft Above Mean Sea Level (AMSL) over Euchanhead. Glasgow PSR and Glasgow Terma have minimum coverage of 5,000ft AMSL over Euchanhead. Note that optimally, NATS' units require 2,000ft of additional PSR coverage below the base of NERL controlled airspace.

The Euchanhead development site lies below the southern part of the Scottish Terminal Control Area (TMA), and east of GPA airspace in the vicinity of the waypoint SUMIN. The TMA has a base of 5,500ft AMSL and aircraft can hold overhead SUMIN at a minimum altitude of 6,000ft. Assuming a tip height of

230m, the elevation of the highest proposed turbine is 843m or 2,770ft AMSL, more than 2,500ft below the base of controlled airspace.

The Ministry of Defence (MOD) has expressed concern that the development site is within Low Flying Area 14 (in fact Low Flying Area 20T), presenting a potential obstruction hazard to military low flying training activities. This impact can be addressed by fitting the turbines with MOD accredited aviation safety lighting.

Full details of the modelling and analysis are contained within the body of this report.

Abbreviations

AGL	Above Ground Level
AIP	Aeronautical Information Publication
AMSL	Above Mean Sea Level
AOD	Above Ordnance Datum
ATC	Air Traffic Control
ATCSMAC	ATC Surveillance Minimum Altitude Chart
ATS	Air Traffic Service
CAA	Civil Aviation Authority
CAD	Computer Aided Design
DOC	Designated Operational Coverage
DTM	Digital Terrain Model
FL	Flight Level
GA	General Aviation
GIS	Geographic Information System
GPA	Glasgow Prestwick Airport
kt	Knot
MOD	Ministry of Defence
NERL	NATS (En Route)
NM	Nautical Miles
PD	Probability of Detection
PSR	Primary Surveillance Radar
RCS	Radar Cross Section
RLoS	Radar Line of Sight
RPM	Revolutions Per Minute
SID	Standard Instrument Departure
SPR	ScottishPower Renewables
SSR	Secondary Surveillance Radar
STAR	Standard Arrival Route
TMA	Terminal Control Area
TMZ	Transponder Mandatory Zone
TOPA	Technical and Operational Assessment
VFR	Visual Flight Rules
VPD	Vertical Polar Diagram

Contents

List of figures

List of tables

1. Introduction

1.1. Background

1.1.1. Cyrrus Limited was commissioned by ScottishPower Renewables (SPR) to undertake an aviation desk study for the proposed Euchanhead Renewable Energy Development site, in Dumfries and Galloway, approximately 9.8km south west of Sanquar, as measured to the nearest turbine. The proposed development is anticipated to comprise up to 21 turbines with a maximum blade tip height of 230m.

1.2. Effects of Wind Turbines on Aviation

1.2.1. Wind turbines are an issue for aviation Primary Surveillance Radars (PSRs) as the characteristics of a moving wind turbine blade are similar to that of an aircraft. As a general rule, 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 impact depends on airspace usage in the vicinity of the wind turbines and the nature of the Air Traffic Service (ATS) provided in that airspace.

1.3. Scoping Responses

1.3.1. Following a request for pre-application scoping advice, responses have been received from the following aviation stakeholders:

Glasgow Airport – 20 February 2020;
NATS (En Route) [NERL] – 20 February 2020;
Ministry of Defence (MOD) – 05 March 2020; and
Glasgow Prestwick Airport (GPA) – 06 April 2020.

1.3.2. Glasgow Airport has no concerns regarding the Development. The MOD identifies that the proposed Development is within Low Flying Area 14 (in fact, it is Low Flying Area 20T) and will cause an obstruction hazard to military low flying training activities. This can be addressed by fitting the Development with MOD accredited aviation safety lighting.

1.3.3. Both NERL and GPA indicate in their responses that they will object to the proposal on the grounds of the proposed turbines being visible to one or more of their PSRs.

1.4. Aviation Modelling Tasks

1.4.1. The initial modelling tasks identified are:

- Determine the radar visibility of the proposed Development to GPA's PSRs;
- Determine the radar visibility of the proposed Development to NERL's PSRs;
- Review the nature of the airspace in the vicinity of Euchanhead to determine any potential impact on aviation.

2. Data

2.1. Euchanhead Renewable Energy Development

2.1.1. A design freeze layout for Euchanhead, dated 26 June 2020, has been issued in the following file:

Euchanhead Design Freeze Infrastructure.lpk.

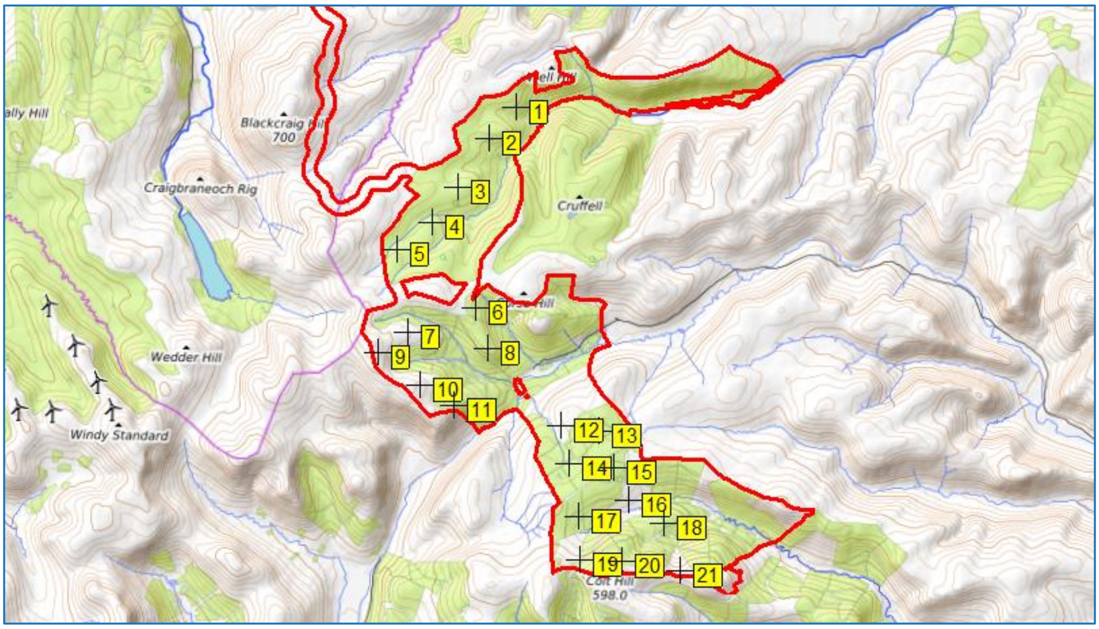
2.1.2. The Ordnance Survey National Grid coordinates for this proposed turbine layout, as used in the assessment, are listed in Table 1.

Turbine	Easting	Northing
1	268456	606531
2	268000	606036
3	267494	605259
4	267071	604688
5	266509	604256
6	267749	603314
7	266646	602924
8	267942	602664
9	266175	602607
10	266848	602093
11	267381	601757
12	269104	601408
13	269707	601291
14	269225	600793
15	269933	600718
16	270156	600193
17	269348	599928
18	270724	599799
19	269363	599239
20	270032	599218
21	270983	599044

Table 1: Euchanhead turbine coordinates

2.1.3. The 21 turbines are planned to have a blade (rotor) diameter of 150m and a maximum blade tip height of 230m AGL.

2.1.4. The proposed turbine layout used for the modelling is shown in Figure 1.



© OpenStreetMap contributors

Figure 1: Proposed turbine layout

2.2. Radar Data

2.2.1. Radar parameters used in the assessment have been taken from data held on file by Cyrrus.

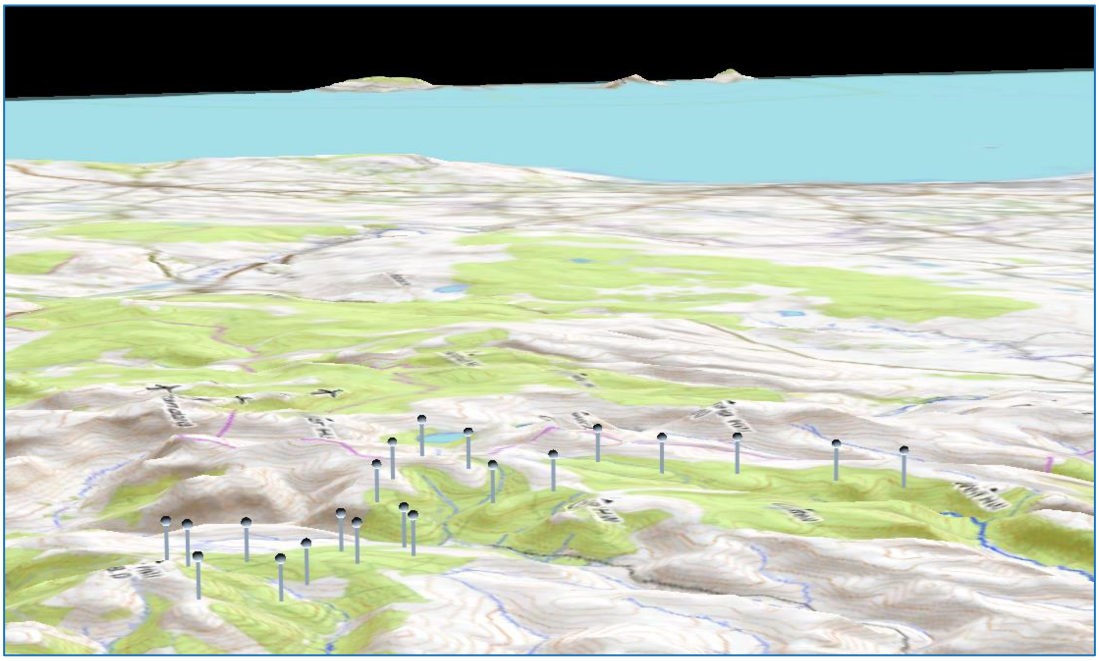
2.3. Analysis Tools

ATDI ICS telecom EV v15.5.3 x64 radio network analysis tool;
Global Mapper v21.1.1 Geographic Information System (GIS) data processing utility;
ZWCAD+ 2015 SP2 Pro v2015.05.26(27086) Computer Aided Design (CAD) software.

2.4. Terrain Data

30m Digital Terrain Model (DTM)

2.4.1. A 3D view of the turbines and the terrain model is shown in Figure 2.



© OpenStreetMap contributors

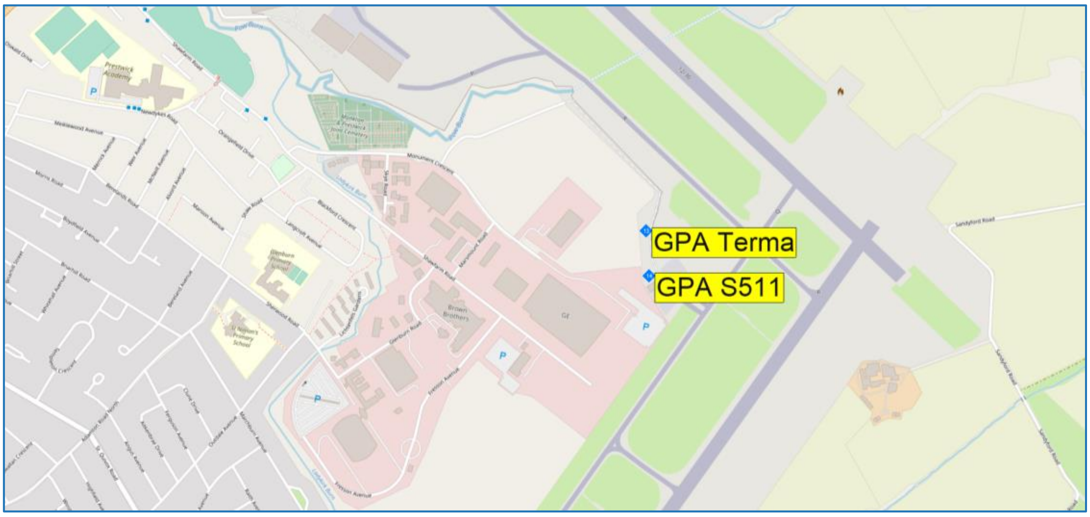
Figure 2: 3D view of turbines and terrain from east

3. GPA Modelling

3.1. Radar Locations

3.1.1. There are two PSR facilities at GPA: a Marconi S511 radar used for planning purposes while a Terma Scanter 4002 radar is used for approach control. In addition, GPA is fed with Secondary Surveillance Radar (SSR) data from Lowther Hill radar. GPA is authorised to use SSR only in the event of PSR failure.

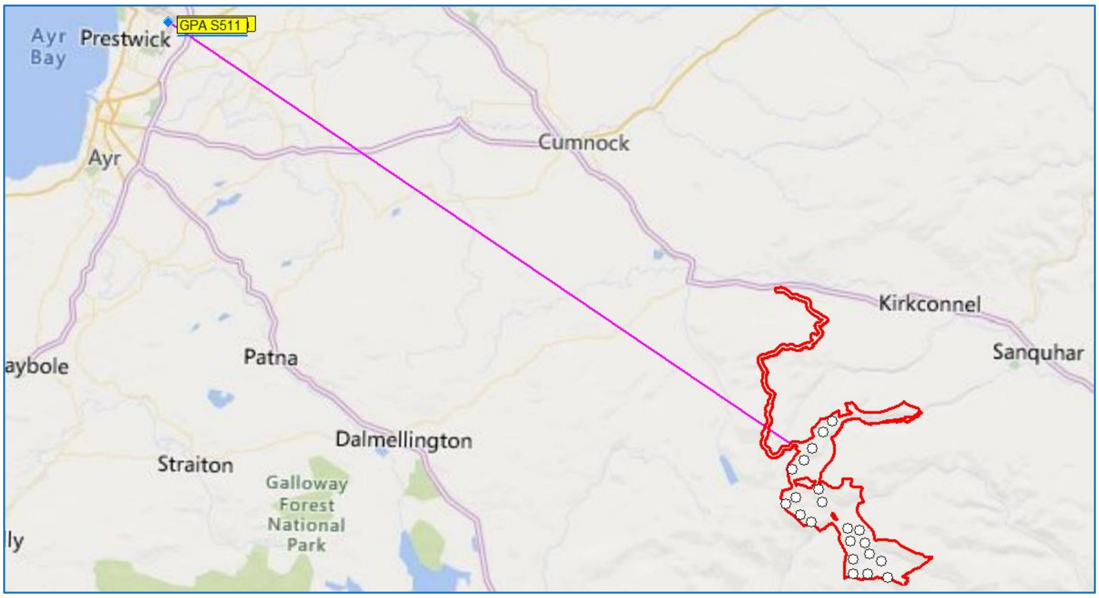
3.1.2. The locations of the two GPA PSRs are shown in Figure 3.



© OpenStreetMap contributors

Figure 3: Locations of GPA Terma PSR and S511 PSR

3.1.3. At its closest point the proposed development area is approximately 36.2km or 19.5 Nautical Miles (NM) south-east of the GPA PSRs, as shown in Figure 4.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 4: Location of GPA PSRs and Euchanhead Renewable Energy Development

3.2. Radar Line of Sight

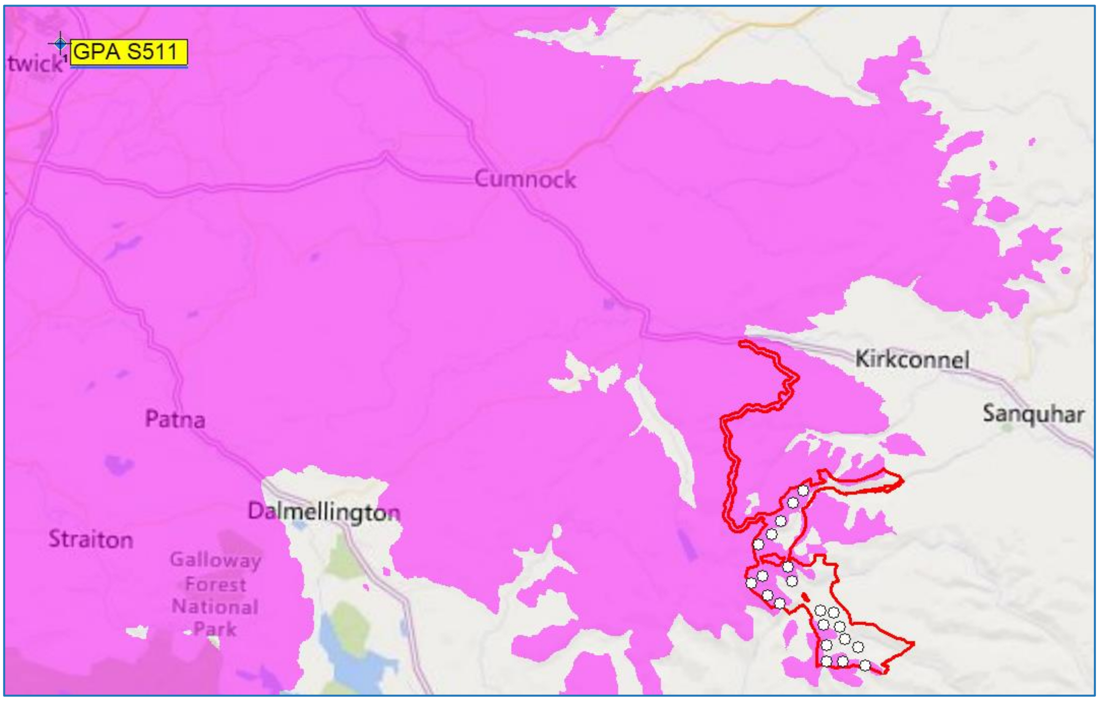
3.2.1. Radar Line of Sight (RLoS) is determined from a radar propagation model (ATDI ICS telecom EV) using 3D DTM data with 30m horizontal resolution. Radar data is entered into the model and RLoS to the turbines from the radar is calculated.

3.2.2. 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 radars and the turbines. Thus, the RLoS assessments are worst-case results.

3.2.3. For PSR, the principal sources of adverse windfarm effects are the turbine blades, so RLoS is calculated for the maximum tip height of the turbines, i.e. 230m AGL.

3.3. RLoS – GPA S511 PSR

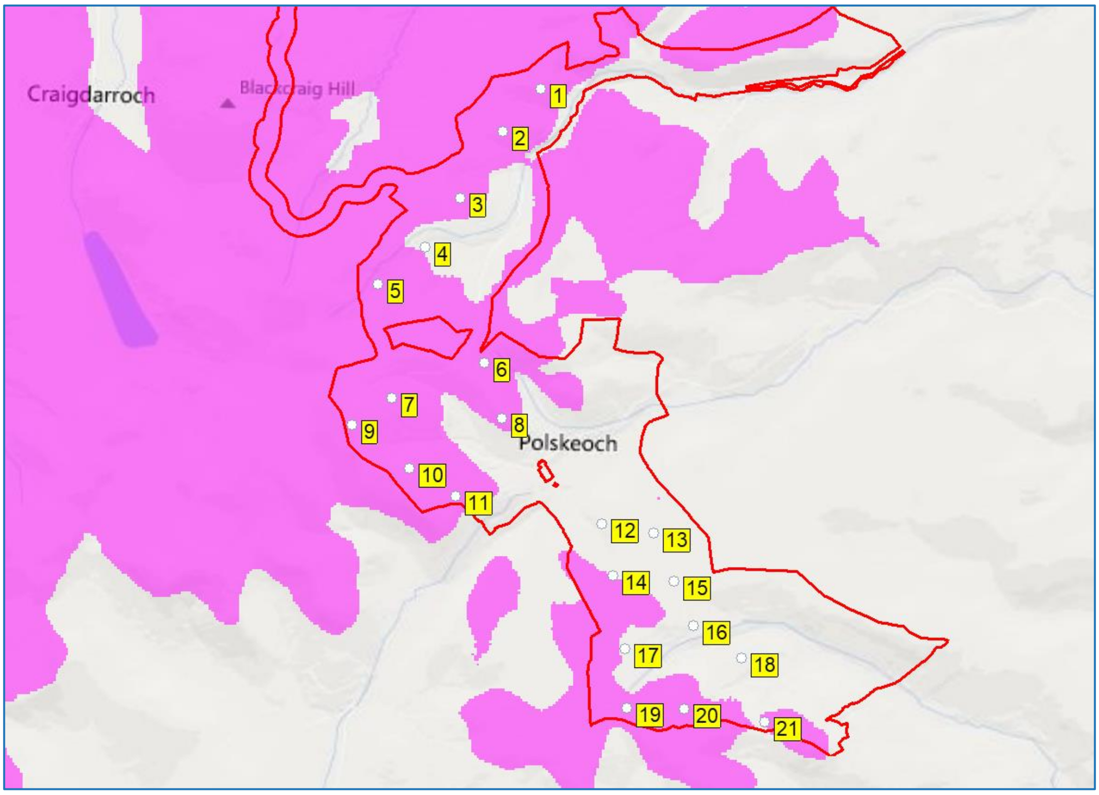
3.3.1. The magenta shading in Figure 5 illustrates the RLoS coverage from the GPA S511 PSR to turbines with a blade tip height of 230m AGL.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 5: GPA S511 PSR RLoS to 230m AGL

3.3.2. The zoomed view of the Development in Figure 6 shows that RLoS exists between the S511 PSR and the blade tips of turbines 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 14, 19, 20 and 21. There is no RLoS between the S511 PSR and turbines 4, 12, 13, 15, 16, 17 and 18.

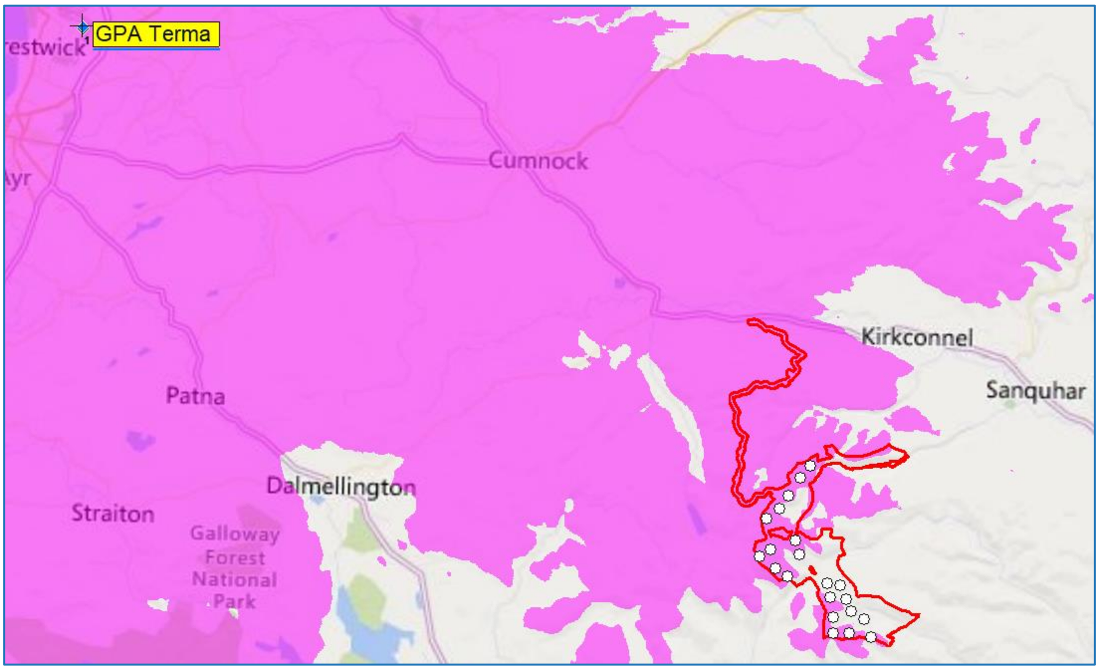


Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 6: GPA S511 PSR RLoS to 230m AGL – zoomed

3.4. RLoS – GPA Terma PSR

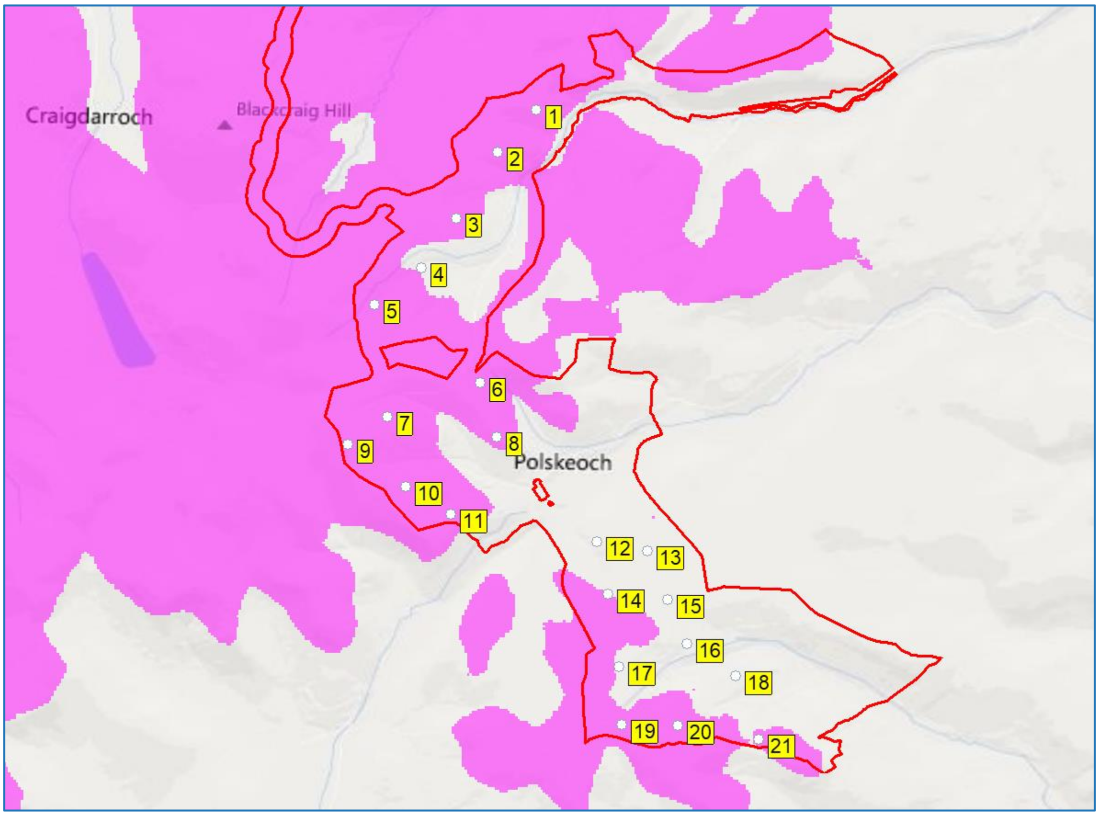
3.4.1. The magenta shading in Figure 7 illustrates the RLoS coverage from the GPA Terma PSR to turbines with a blade tip height of 230m AGL.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 7: GPA Terma PSR RLoS to 230m AGL

3.4.2. The zoomed view of the Development in Figure 8 shows that, similarly to the S511 PSR, RLoS exists between the Terma PSR and the blade tips of turbines 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 14, 19, 20 and 21. Again, there is no RLoS between the Terma PSR and turbines 4, 12, 13, 15, 16, 17 and 18.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 8: GPA Terma PSR RLoS to 230m AGL – zoomed

3.5. Probability of Detection

3.5.1. When RLoS exists between a radar and a turbine it can generally be assumed that the radar will detect the turbines.

3.5.2. If there is no RLoS between a radar and a turbine then the radar may not detect the turbine, however, this can only be assured by analysis of the path profile between the radar and turbine and conducting Probability of Detection (PD) calculations.

3.5.3. Using a radar propagation model, the actual path loss between the GPA PSRs and various parts of each turbine can be determined.

3.6. PD - GPA S511 PSR

3.6.1. Figure 9 illustrates the path loss profile between the GPA S511 PSR and turbine 1.

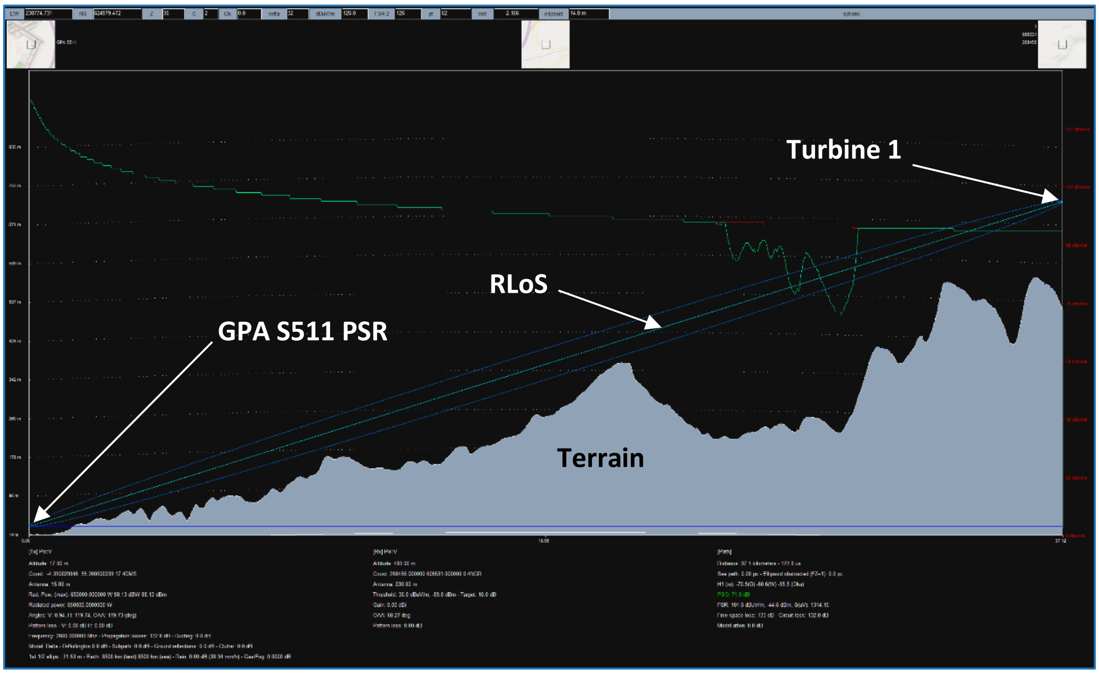


Figure 9: Path loss profile between GPA S511 PSR and tip of turbine 1

3.6.2. In Figure 9 the terrain, shaded grey, lies entirely below the path between the PSR and the turbine tip. Thus, the S511 PSR has uninterrupted RLoS to the tip of turbine 1 and it can be assumed that the PSR will detect this turbine.

3.6.3. Figure 10 illustrates the path loss profile between the S511 PSR and turbine 4.

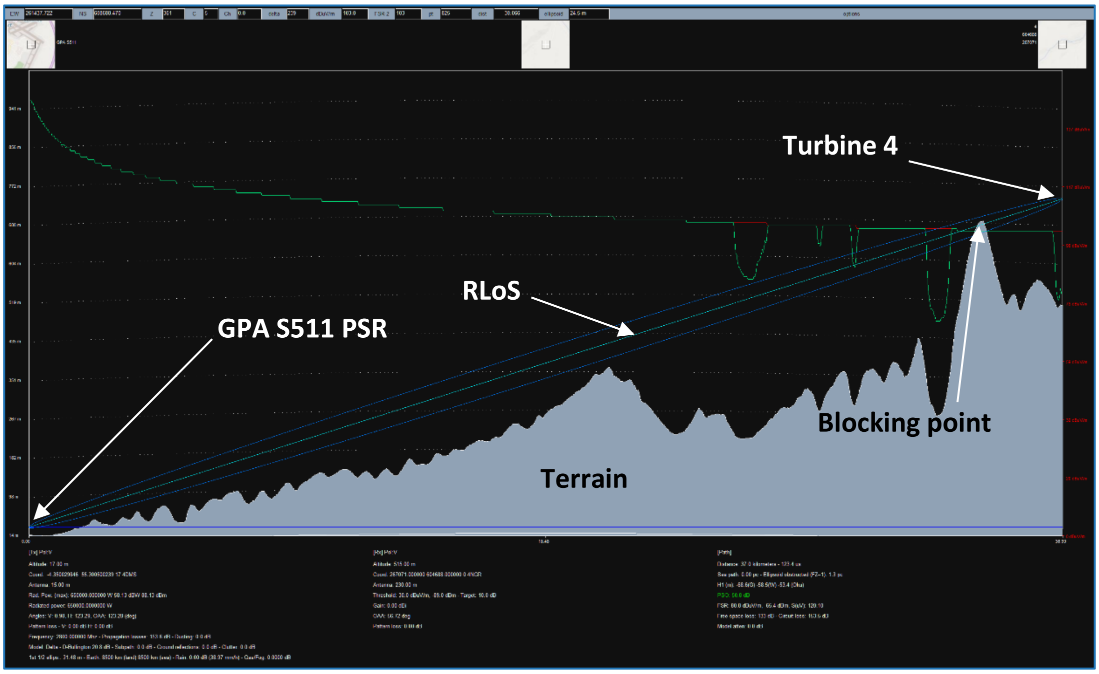


Figure 10: Path loss profile between GPA S511 PSR and tip of turbine 4

3.6.4. In this instance, a peak in the terrain penetrates the path between the PSR and the turbine tip. The indicated blocking point prevents the S511 PSR from having RLoS to turbine 4.

3.6.5. All of the path profiles between the S511 PSR and the 21 Euchanhead turbines are shown in Annex A at the end of this report.

3.6.6. Even when intervening terrain blocks RLoS between the radar and a turbine, the probability that the turbine will be detected by the radar is still dependant on several factors including the radar's power, radar signal path loss, the angle of antenna tilt and distance to the object.

3.6.7. 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.

3.6.8. 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 $60m^2$ based on a blade length of 75m (half of 150m 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.

3.6.9. 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 (60m^2 ~ +48dB@2800MHz)
-	Path Loss	dB
+	Antenna Gain	dB
=	Received Signal	dBm

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

3.6.11. An example of the path loss calculation from the GPA S511 to turbine 1 is shown in Figure 11.

Radar 2-Way Path Loss Calculator

Data		
Tx Frequency	2800	MHz
Tx Power	650000	Watts
Antenna Gain	31.5	dBi
Rx Sensitivity	-107.2	dBm

Target		
RCS	60	m^2
Path Loss (1-way)	132.8	dB

Calculations		
Tx Wavelength	0.11	m
Tx power	88.12913	dBm
EIRP	119.6291	dBm
Power at Target	-13.1709	dBm
RCS Gain	48.18	dB
Power at Rx	-66.29	dBm
dB over Rx Threshold	40.91	dB

Figure 11: GPA S511 path loss calculation for turbine 1

3.6.12. The two-way path losses from the turbine components are tabulated and combined to give total radar received signals from each turbine. The results are colour-coded to indicate the likelihood of detection. Radar returns >3dB above the detection threshold are coloured green as these values show a high probability of detection. Those between +3dB and -3dB are coloured yellow and indicate a possibility of detection. Between -3dB and -6dB, results are coloured orange to show only a small possibility of detection. Signals >6dB below the threshold of detection are shaded red as these values show that detection is unlikely.

3.6.13. Using this representation provides a ready visual comparison of different scenarios. The final result is shown in the final column (TOTAL) of each colour-coded chart.

3.6.14. The results of the GPA S511 PSR PD calculations for each turbine are shown in Table 2.

Turbine ID	Turbine Nacelle	Blade mid-point	Blade Tip	TOTAL
	Path Loss dB	Path Loss dB	Path Loss dB	dB over RX threshold
1	143.7	132.8	132.8	**43.94**
2	138.2	132.7	132.7	**44.29**
3	167.2	154.5	132.7	**41.11**
4	172.5	167.2	153.6	**-0.68**
5	132.7	132.7	132.7	**45.88**
6	136.5	133.1	133.1	**43.75**
7	132.9	132.9	132.9	**45.48**
8	163.3	138.0	133.2	**40.56**
9	132.9	132.9	132.9	**45.48**
10	133.1	133.1	133.1	**45.08**
11	152.8	133.2	133.2	**43.12**
12	176.9	174.6	171.4	**-35.12**
13	173.5	170.1	164.3	**-21.74**
14	169.7	163.2	145.9	**14.71**
15	175.1	172.4	168.6	**-29.81**
16	175.4	173.0	169.6	**-31.62**
17	172.2	167.3	156.2	**-5.86**
18	176.4	174.3	171.7	**-35.37**
19	162.6	152.4	136.5	**33.52**
20	142.7	134.0	134.0	**41.56**
21	168.4	161.3	140.8	**24.91**

Table 2: GPA S511 PSR PD results

3.6.15. From Table 2 it appears that turbines 12, 13, 15, 16 and 18 are unlikely to be detected by the GPA S511 PSR. There is a small possibility of turbine 17 being detected and a possibility of turbine 4 being detected.

3.6.16. 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 horizonal but having high gain at elevations just a few degrees above the horizon.

3.6.17. The S511 PSR uses a Watchman antenna which usually has a maximum gain 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 gain profile.

3.6.18. A radar Vertical Polar Diagram (VPD) plots antenna gain data as a smoothed line versus elevation to enable intermediate values of antenna gain to be determined.

3.6.19. Watchman VPD data is shown in Figure 12.

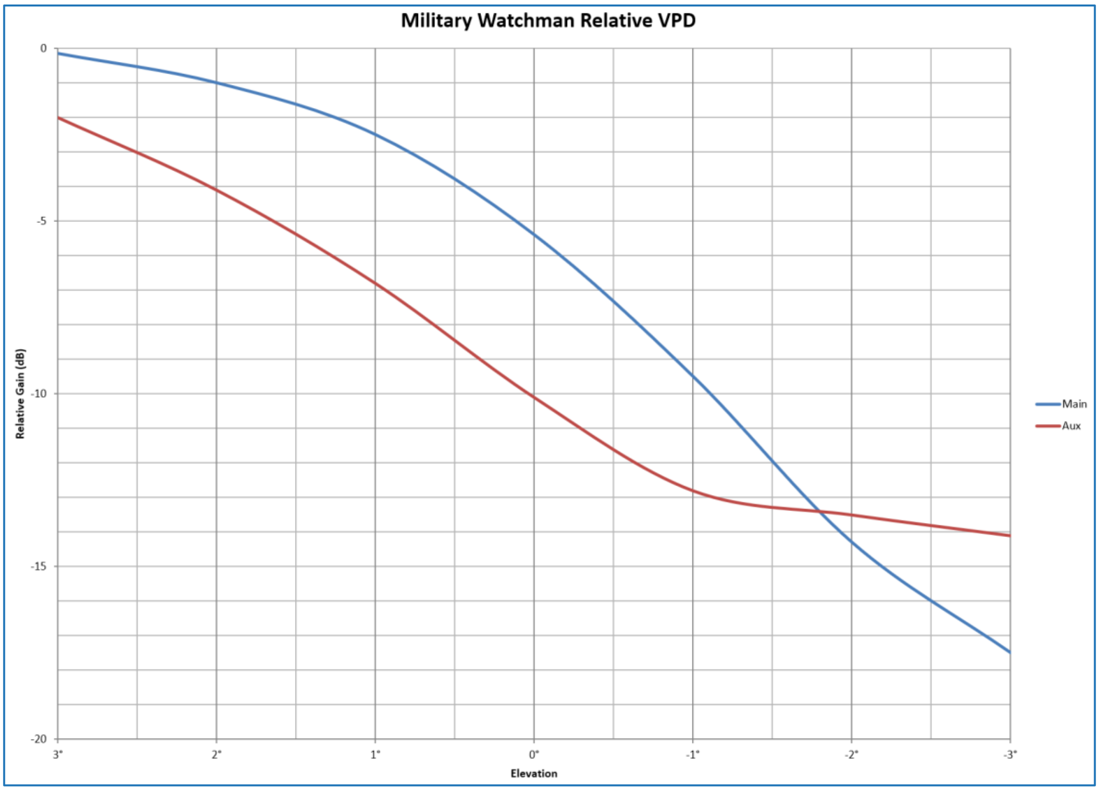


Figure 12: Watchman antenna VPD

3.6.20. The Watchman is a dual beam antenna. At short ranges (less than around 19km) the radar uses a high, or auxiliary, beam to reduce the effects of close in ground clutter. Beyond these ranges a low, or main, beam is used. Euchanhead lies in the S511 PSR's main beam area.

3.6.21. The vertical angle from the S511 PSR to the tips of the turbines varies between +0.7° and +1.1°. The GPA S511 PSR has a mechanical tilt of 0° so this means a main beam gain reduction of approximately -2.5dB at these elevations.

3.6.22. Table 3 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	143.7	132.8	132.8	**38.94**
2	138.2	132.7	132.7	**39.29**
3	167.2	154.5	132.7	**36.11**
4	172.5	167.2	153.6	**-5.68**
5	132.7	132.7	132.7	**40.88**
6	136.5	133.1	133.1	**38.75**
7	132.9	132.9	132.9	**40.48**
8	163.3	138.0	133.2	**35.56**
9	132.9	132.9	132.9	**40.48**

Turbine ID	Turbine Nacelle	Blade mid-point	Blade Tip	TOTAL
	Path Loss dB	Path Loss dB	Path Loss dB	dB over RX threshold
10	133.1	133.1	133.1	**40.08**
11	152.8	133.2	133.2	**38.12**
12	176.9	174.6	171.4	**-40.12**
13	173.5	170.1	164.3	**-26.74**
14	169.7	163.2	145.9	**9.71**
15	175.1	172.4	168.6	**-34.81**
16	175.4	173.0	169.6	**-36.62**
17	172.2	167.3	156.2	**-10.86**
18	176.4	174.3	171.7	**-40.37**
19	162.6	152.4	136.5	**28.52**
20	142.7	134.0	134.0	**36.56**
21	168.4	161.3	140.8	**19.91**

Table 3: GPA S511 PSR PD results – corrected for VPD

3.6.23. From Table 3 it now appears that turbine 17 is additionally unlikely to be detected, while turbine 4 only has a small possibility of detection.

3.6.24. The PD calculations show that 6 of the 7 turbines that are not in RLoS of the S511 PSR are unlikely to be detected by the radar, while turbine 4 has a small possibility of detection.

3.7. PD – GPA Terma PSR

3.7.1. Figure 13 illustrates the path loss profile between the GPA Terma PSR and turbine 6.

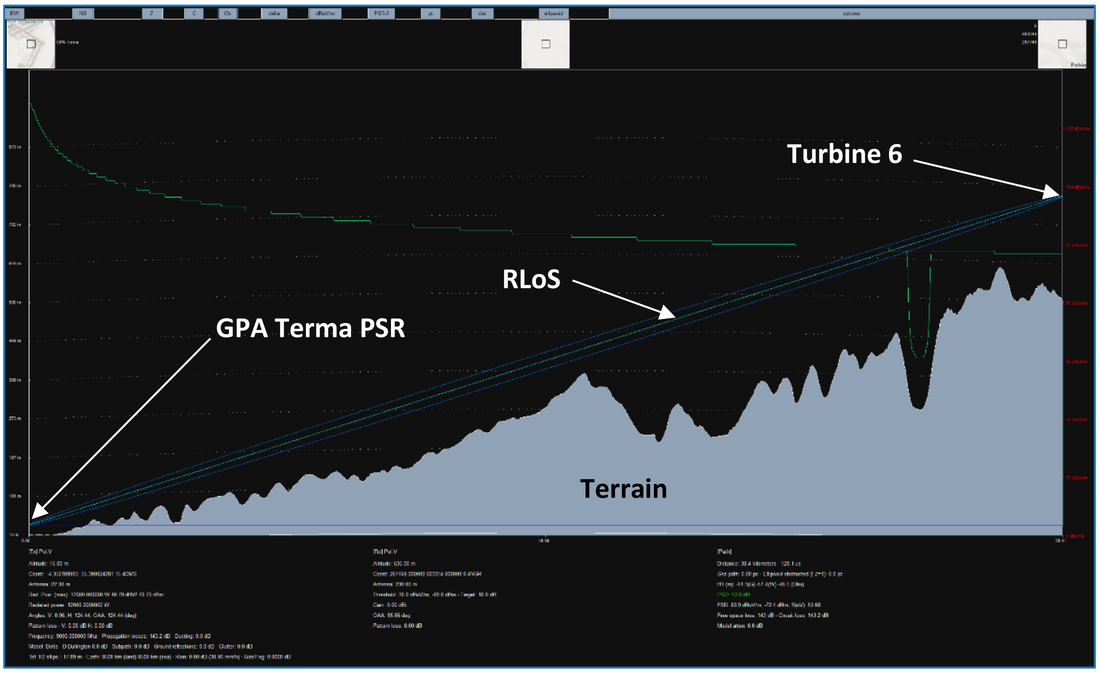


Figure 13: Path loss profile between GPA Terma PSR and tip of turbine 6

3.7.2. In Figure 13 the terrain, shaded grey, lies entirely below the path between the PSR and the turbine tip. Thus, the Terma PSR has uninterrupted RLoS to the tip of turbine 6 and it can be assumed that the PSR will detect this turbine.

3.7.3. Figure 14 illustrates the path loss profile between the Terma PSR and turbine 12.

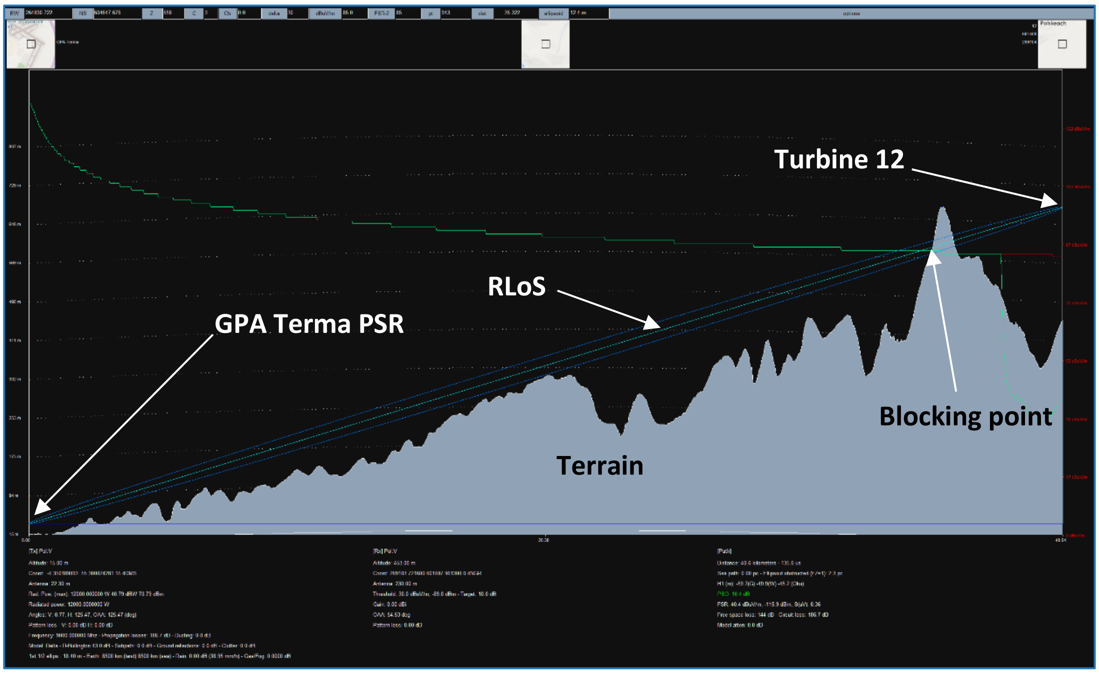


Figure 14: Path loss profile between GPA Terma PSR and tip of turbine 12

3.7.4. In this instance, a peak in the terrain penetrates the path between the PSR and the turbine tip. The indicated blocking point prevents the Terma PSR from having RLoS to turbine 12.

3.7.5. All of the path profiles between the Terma PSR and the 21 Euchanhead turbines are shown in Annex B at the end of this report.

3.7.6. Even when intervening terrain blocks RLoS between the radar and a turbine, the probability that the turbine will be detected by the radar is still dependant on several factors including the radar's power, radar signal path loss, the angle of antenna tilt and distance to the object.

3.7.7. 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 RCS gain, the probability of the radar detecting the target (PD) can be calculated.

3.7.8. 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 $60m^2$ based on a blade length of 75m (half of 150m 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.

3.7.9. 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 (60m^2 ~ +58dB@9000MHz)
-	Path Loss	dB
+	Antenna Gain	dB
=	Received Signal	dBm

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

3.7.11. An example of the path loss calculation from the GPA Terma to turbine 1 is shown in Figure 15.

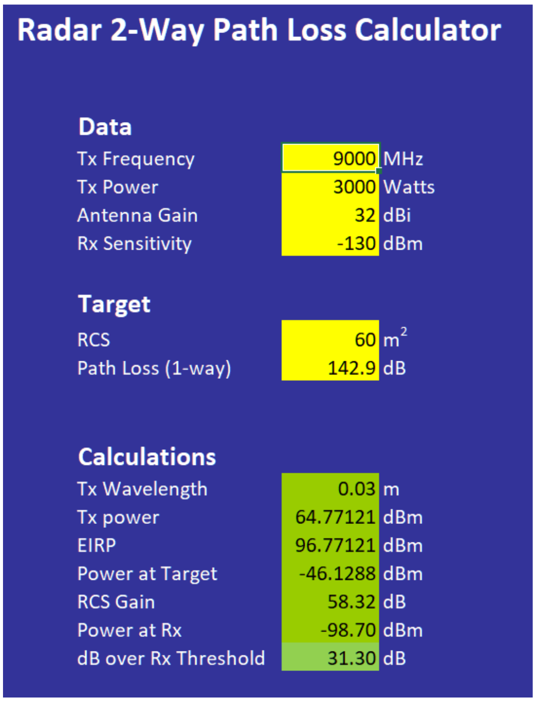


Figure 15: GPA Terma path loss calculation for turbine 1

3.7.12. The two-way path losses from the turbine components are tabulated and combined to give total radar received signals from each turbine. The results are colour-coded to indicate the likelihood of detection. Radar returns >3dB above the detection threshold are coloured green as these values show a high probability of detection. Those between +3dB and -3dB are coloured yellow and indicate a possibility of detection. Between -3dB and -6dB, results are coloured orange to show only a small possibility of detection. Signals >6dB below the threshold of detection are shaded red as these values show that detection is unlikely.

3.7.13. Using this representation provides a ready visual comparison of different scenarios. The final result is shown in the final column (TOTAL) of each colour-coded chart.

3.7.14. The results of the GPA Terma PSR PD calculations for each turbine are shown in Table 4.

Turbine ID	Turbine Nacelle	Blade mid-point	Blade Tip	TOTAL
	Path Loss dB	Path Loss dB	Path Loss dB	dB over RX threshold
1	148.2	142.9	142.9	**34.49**
2	142.9	142.9	142.9	**36.07**
3	182.4	168.8	142.9	**31.30**
4	187.9	182.7	168.8	**-20.50**
5	142.9	142.9	142.9	**36.07**
6	143.2	143.2	143.2	**35.47**
7	143.1	143.1	143.1	**35.67**
8	177.8	143.3	143.3	**33.51**
9	143.0	143.0	143.0	**35.87**
10	143.2	143.2	143.2	**35.47**
11	166.4	143.4	143.4	**33.31**
12	192.1	189.8	186.7	**-55.09**
13	188.6	185.1	179.2	**-40.97**
14	185.0	178.4	155.0	**7.10**
15	190.3	187.7	183.8	**-49.65**
16	191.0	188.6	185.5	**-52.70**
17	187.4	182.5	170.5	**-23.89**
18	191.7	189.7	187.1	**-55.57**
19	177.0	163.3	144.0	**29.10**
20	144.1	144.1	144.1	**33.67**
21	183.4	175.7	144.3	**28.50**

Table 4: GPA Terma PSR PD results

3.7.15. From Table 4 it appears that turbines 4, 12, 13, 15, 16, 17 and 18 are unlikely to be detected by the GPA Terma PSR.

3.7.16. 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.

3.7.17. It is likely that the turbine tip elevations from the Terma PSR (between +0.7° and +1.1°) are below the peak elevation of the beam where gain is maximum. However, although any reduction in gain will further reduce the probability of turbine detection, it is unlikely that this will have any significant impact on the 'green' values.

3.7.18. The PD calculations confirm that all the turbines that are not in RLoS of the Terma PSR are unlikely to be detected by the radar.

3.8. Impact of Detected Turbines – GPA S511 PSR

3.8.1. The GPA S511 PSR was installed in 1990, and today is primarily used as a planning radar. The newly installed Terma PSR is effectively a replacement for this legacy radar but is limited to a range of approximately 40NM, so the S511 is used for traffic beyond this range.

3.8.2. If for some reason the Terma approach radar becomes unserviceable then the radar control service would continue using Lowther Hill SSR data only, albeit with a minimum traffic separation increase from 5NM to 10NM.

3.9. Impact of Detected Turbines – GPA Terma PSR

3.9.1. The newly installed GPA Terma Scanter 4002 PSR was introduced as a windfarm tolerant approach radar and was funded through windfarm operators. The Terma PSR operates in the X frequency band (9GHz), unlike the majority of PSRs providing approach services which operate in the S band (2.8GHz). This means that the Terma antenna transmits a narrower beam with smaller range resolutions down to approximately 6m as opposed to 50m.

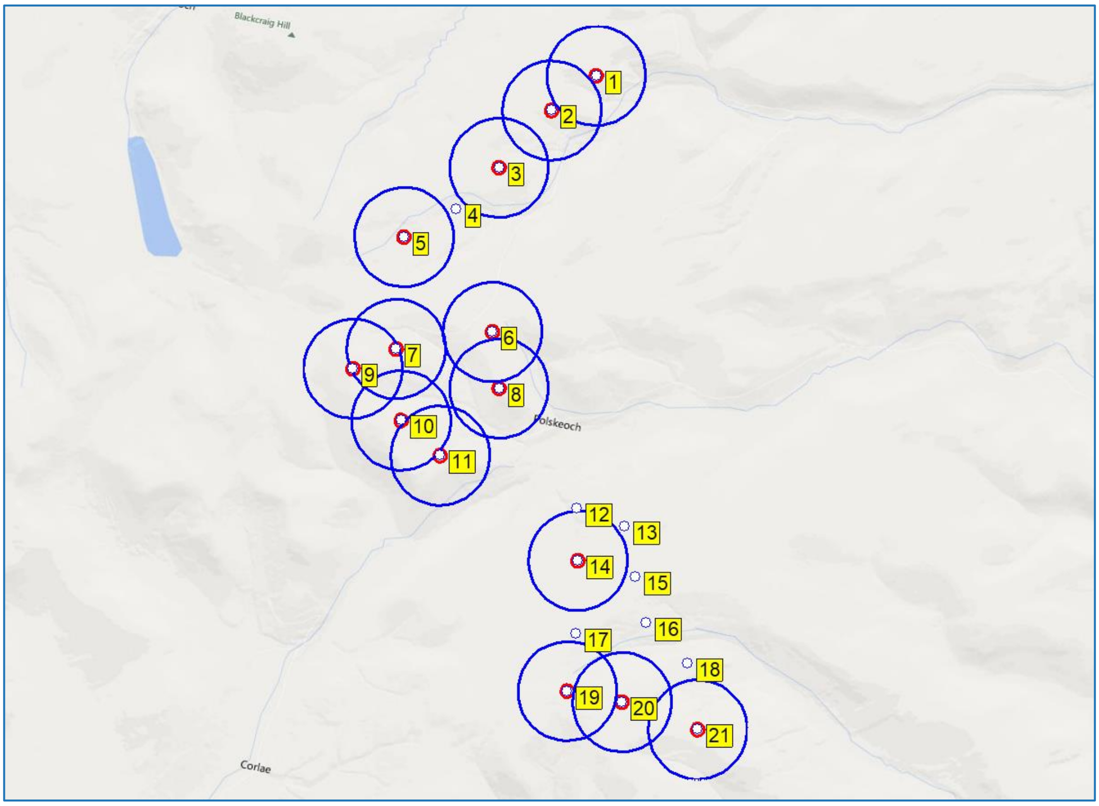
3.9.2. The resolution of the Terma PSR allows it to effectively mask out individual turbines. To mask the turbines the radar blanks the area around each turbine. The required minimum size of each turbine blank is a geographic polygon defined in terms of range and sector angles from the Terma PSR sufficient to contain a circle of 150m in diameter. This diameter is the minimum size necessary to encompass the turbine blades for all turbine orientations.

3.9.3. Within the blanked area no targets are detected. This includes airborne targets as well as turbine blades. If an airborne target is not detected for three consecutive radar scans then its track will be dropped, thus the distance between turbines, and hence blanked areas, within the windfarm becomes critical.

3.9.4. The GPA Terma PSR has a scan rate of 15 Revolutions Per Minute (RPM) which equates to a time interval of 4 seconds between scans. Aircraft being tracked by the Terma PSR are generally low-level (7,000ft Above Mean Sea Level (AMSL) at most) with groundspeeds typically between 125 knots (kt) and 250kt. (Civilian aircraft are limited to a speed of 250kt for flights below 10,000ft). If the highest groundspeed is assumed, then an airborne target can travel up to 515m between radar scans.

3.9.5. A simple analysis can be undertaken to assess the likelihood of a dropped track for airborne targets crossing the proposed Development.

3.9.6. In Figure 16 the small red circles are an idealised representation of the blanked area around each of the turbines likely to be detected. The blue circles represent the maximum range that an aircraft can travel from the perimeter of each blanked area in a single radar scan, assuming a groundspeed of 250kt.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 16: Maximum range from detected turbines for aircraft at 250kt

3.9.7. It can be seen that the maximum ranges from turbines 9 and 7, and from turbines 10 and 11, overlap their respective blanked areas. This means that in theory an aircraft travelling between the vicinities of turbines 9 and 7 or 10 and 11 may not be detected on two consecutive radar scans.

3.9.8. For an aircraft to not be detected on three consecutive radar scans, resulting in a dropped track, the aircraft groundspeed needs to be in excess of 250kt.

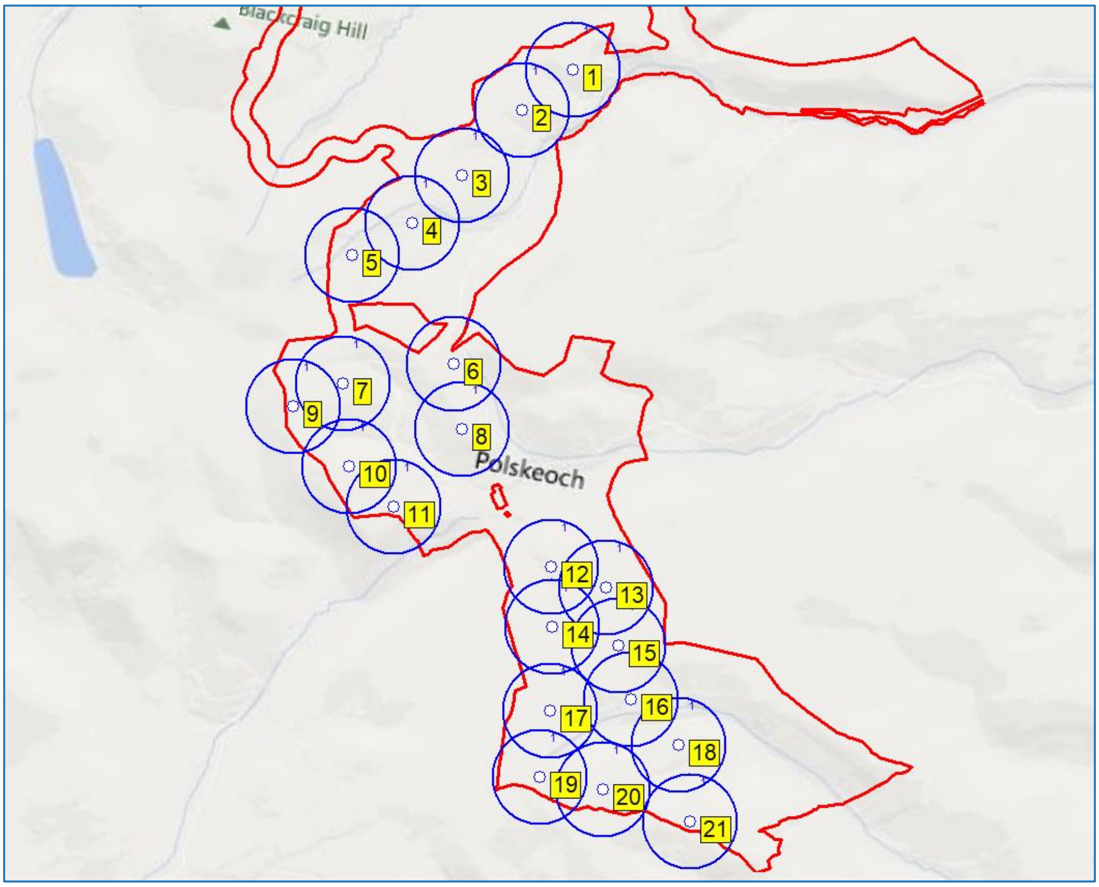
3.9.9. A white paper published on the Terma website, "Detection and Tracking of Aircraft over Wind Farms using SCANTER 4002 with Embedded Tracker 2"[1], comprehensively presents the details and results of flight tests carried out over large offshore windfarms. Part 3 of the document confirms that a software feature of the Terma can be enabled to manually mask out wind turbines in the produced video. However, masking of turbines reduces radar sensitivity. In the example given in the document, masking reduces the probability of detection from 96% to 58%.

3.9.10. The document concludes that for windfarms with an inter-turbine spacing of 500m or more the best results are found by allowing the turbine video to be extracted as plots to be used in the tracker and identified as static targets. Once established as static targets, they will

[1] https://www.terma.com/media/210262/detection_and_tracking_of_aircraft_over_wind_farms_using_scanter_4002.pdf

have high association likelihood to new plots overlapping the track updated position, and thereby help consume wind turbine plots and lower the risk of track seductions.

3.9.11. Blue circles of 500m radius centred on each turbine in Figure 17 shows that the Euchanhead turbines have the required inter-turbine spacing.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 17: 500m inter-turbine spacing

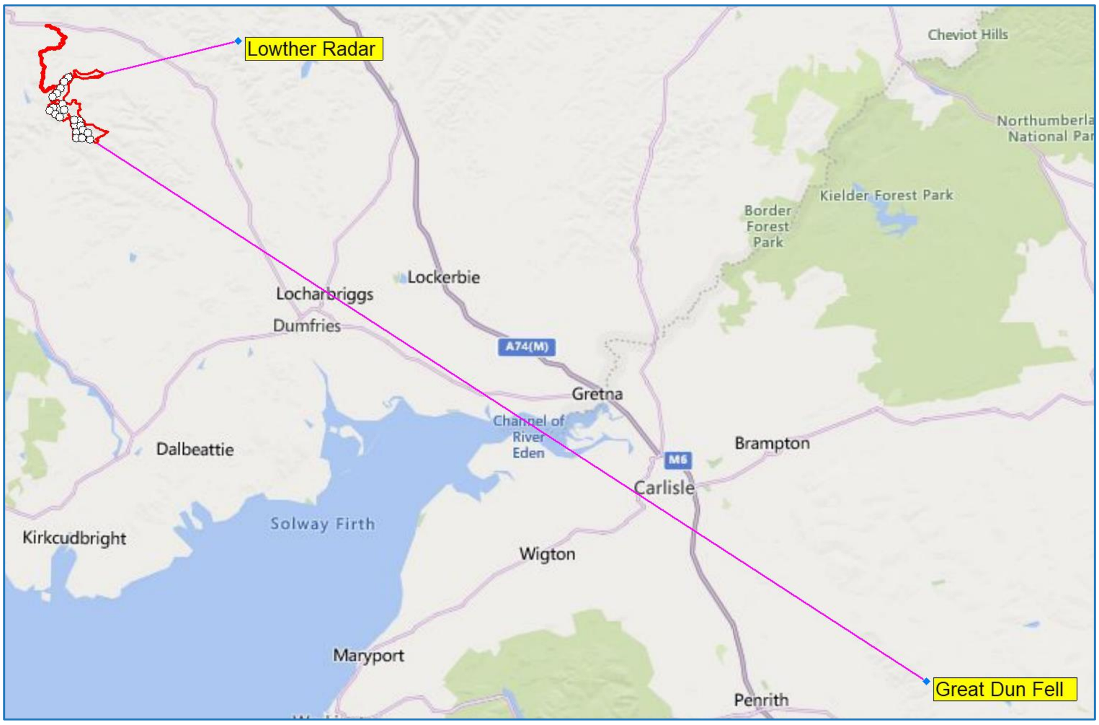
3.9.12. The GPA Terma should be capable of automatically detecting the Euchanhead turbines and maintaining internal tracks on them (which are not displayed to the controller) whilst simultaneously tracking air targets passing over the proposed Development. Note that the Terma can maintain more than 1000 concurrent internal tracks without a degradation to the display so the additional processor load from maintaining tracks on the 14 detected turbines would be negligible. In other words, the inherent processing capabilities of the GPA Terma should be able to mitigate the impact of the RLoS turbines without any further intervention.

4. NERL Modelling

4.1. Radar Locations

4.1.1. In their Technical and Operational Assessment (TOPA)[2], NERL identify the en-route PSRs at Lowther Hill and Great Dun Fell as being technically impacted by the proposed Development.

4.1.2. At its closest points, the proposed development area is approximately 16.7km or 9.0NM west of Lowther Hill PSR and 119.5km or 64.5NM north-west of Great Dun Fell PSR, as shown in Figure 18.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 18: Location of Lowther Hill and Great Dun Fell PSRs and Euchanhead Renewable Energy Development

4.2. Radar Line of Sight

4.2.1. RLoS is determined from a radar propagation model (ATDI ICS telecom EV) using 3D DTM data with 30m horizontal resolution. Radar data is entered into the model and RLoS to the turbines from the radar is calculated.

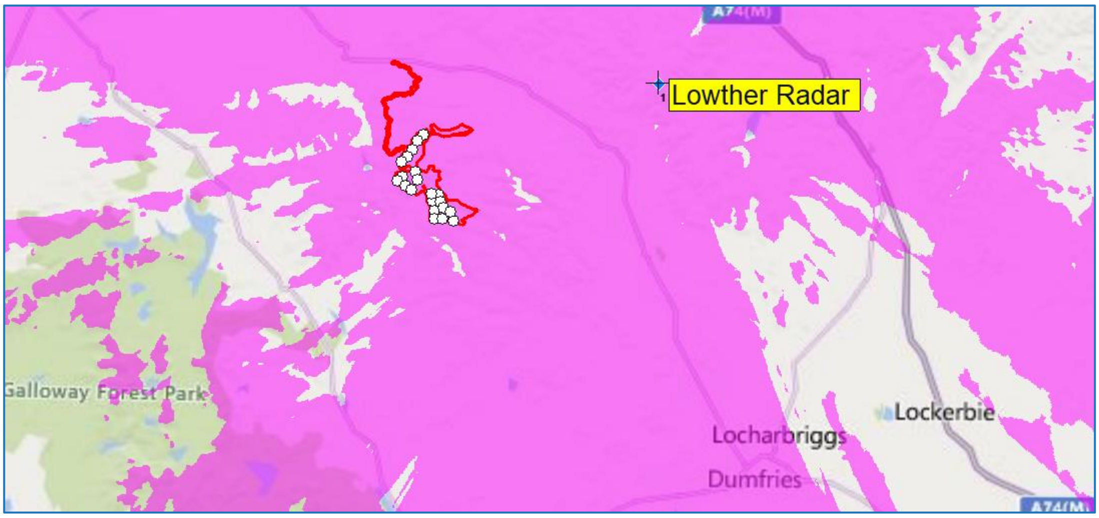
4.2.2. Note that by using a DTM no account is taken of possible further shielding of the turbines due to the presence of structures or vegetation that may lie between the radars and the turbines. Thus, the RLoS assessments are worst-case results.

[2] Technical and Operational Assessment (TOPA) For Euchanhead Wind Farm Development, NATS ref: SG29382, Issue 1, February 2020

4.2.3. For PSR, the principal sources of adverse windfarm effects are the turbine blades, so RLoS is calculated for the maximum tip height of the turbines, i.e. 230m AGL.

4.3. RLoS – Lowther Hill PSR

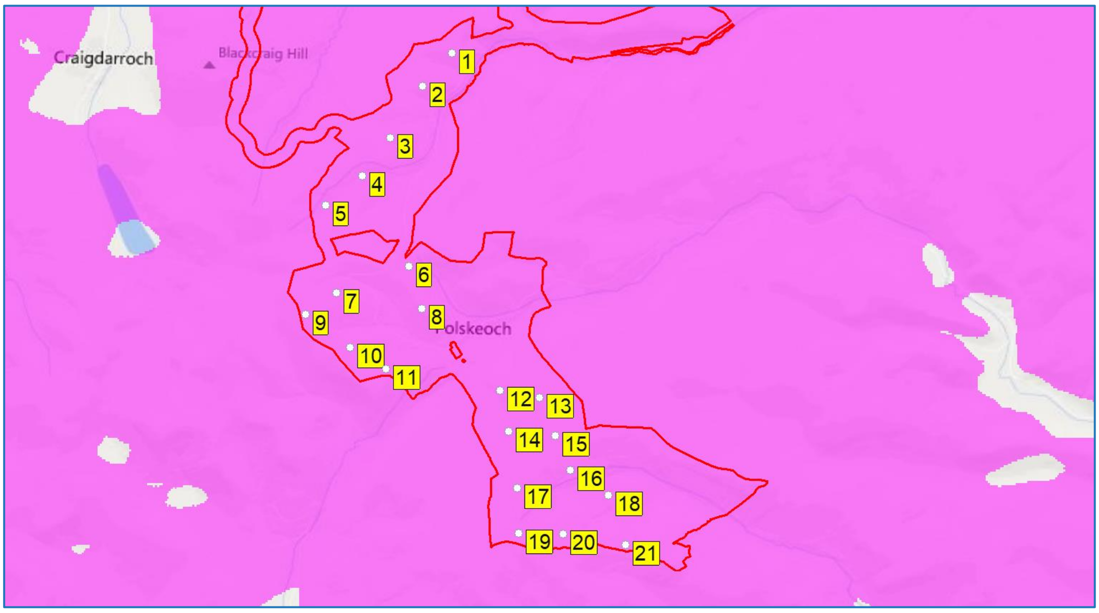
4.3.1. The magenta shading in Figure 19 illustrates the RLoS coverage from Lowther Hill PSR to turbines with a blade tip height of 230m AGL.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 19: Lowther Hill PSR RLoS to 230m AGL

4.3.2. The zoomed view of the Development in Figure 20 shows that RLoS exists between Lowther PSR and all 21 turbines.



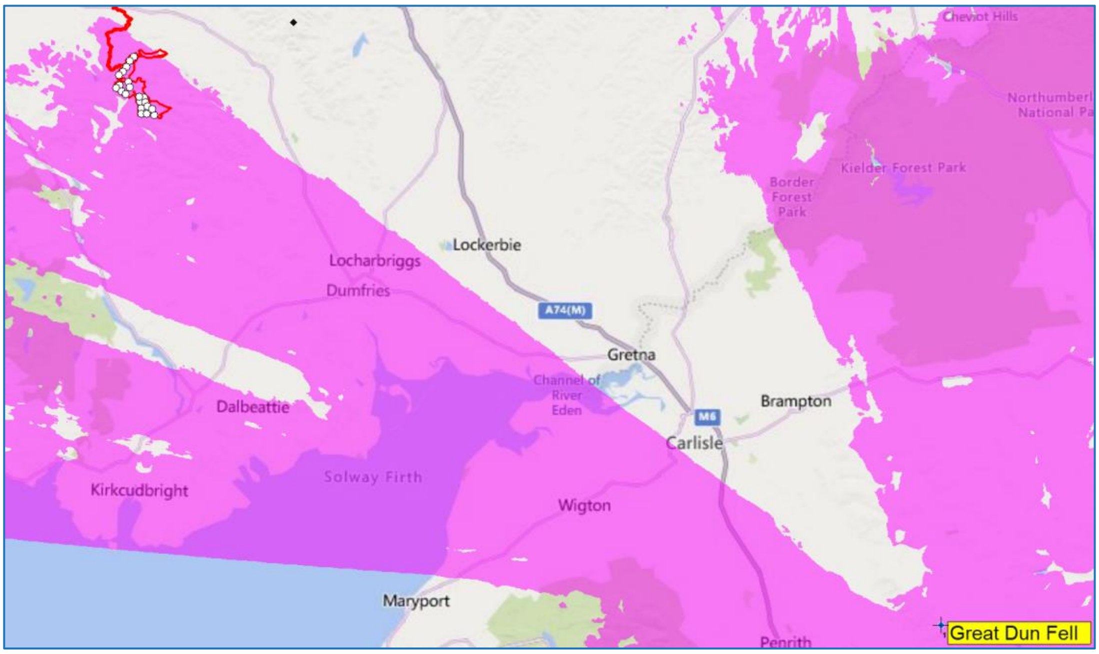
Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 20: Lowther Hill PSR RLoS to 230m AGL – zoomed

4.3.3. Given that RLoS exists to all the turbines, it can be assumed that Lowther Hill PSR will also detect all 21 turbines.

4.4. RLoS – Great Dun Fell PSR

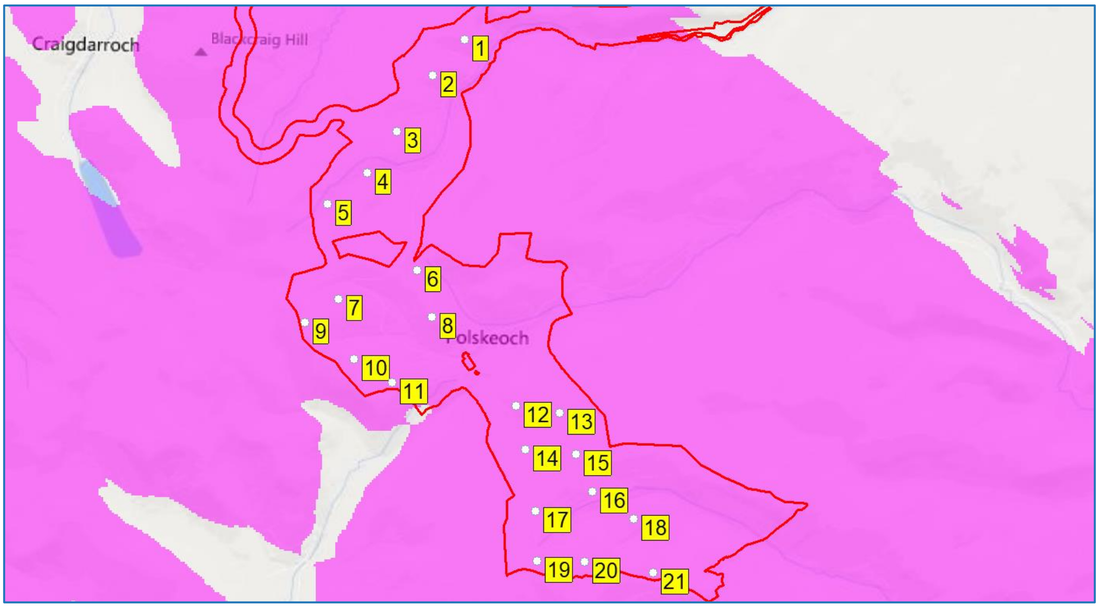
4.4.1. The magenta shading in Figure 21 illustrates the RLoS coverage from Great Dun Fell PSR to turbines with a blade tip height of 230m AGL.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 21: Great Dun Fell PSR RLoS to 230m AGL

4.4.2. The zoomed view of the Development in Figure 22 shows that RLoS exists between Great Dun Fell PSR and all 21 turbines.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 22: Great Dun Fell PSR RLoS to 230m AGL – zoomed

4.4.3. Given that RLoS exists to all the turbines, it can be assumed that Great Dun Fell PSR will also detect all 21 turbines.

4.5. Mitigation – Potential Infill Radars

4.5.1. A potential option for mitigating the impact on these NERL radars is to use an infill radar feed that does not have RLoS of the Euchanhead turbines but has adequate coverage over the Euchanhead site to satisfy Air Traffic Control requirements.

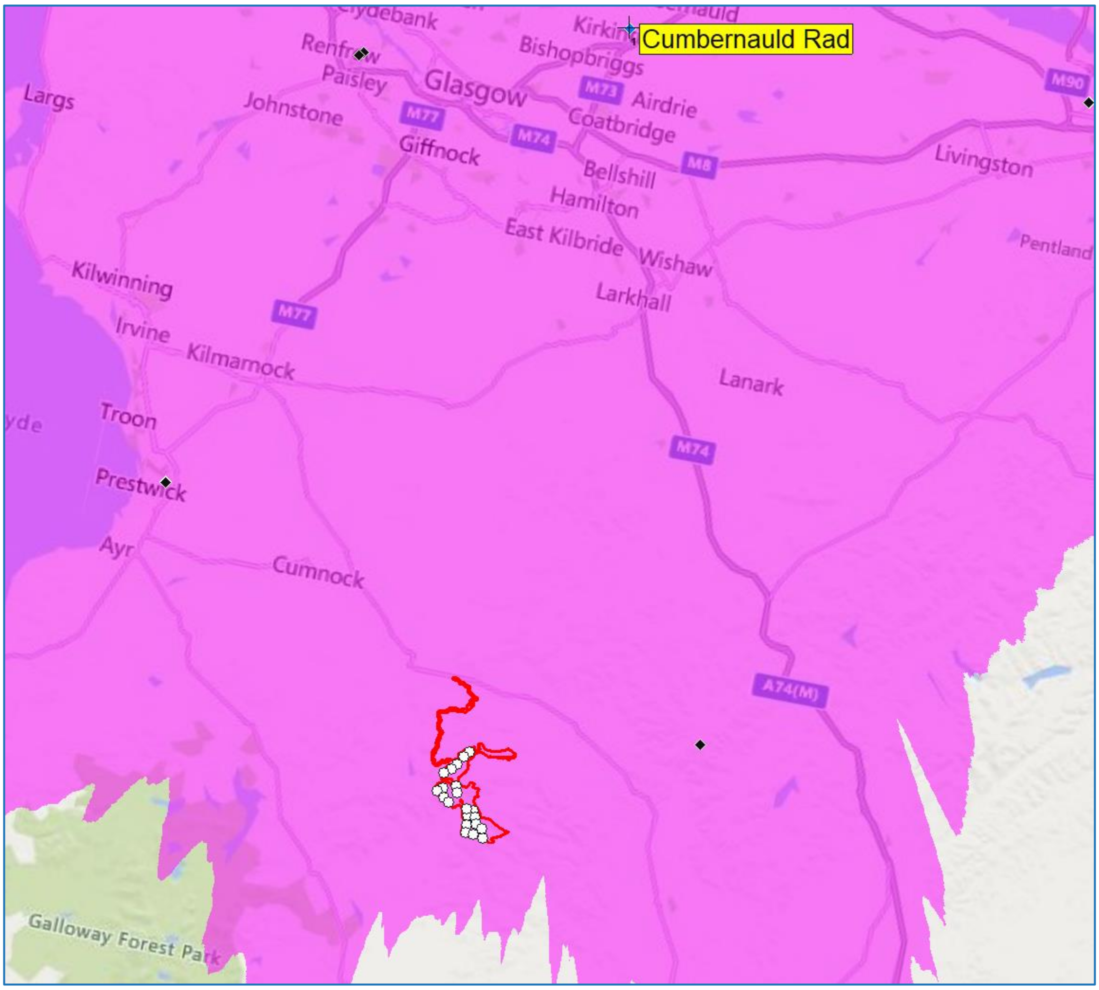
4.5.2. The base of controlled airspace immediately above Euchanhead is at an altitude of 5,500ft AMSL. This airspace is under the control of NERL, based at Prestwick Centre, however airspace in the vicinity of GPA from 5,500ft to 6,000ft is delegated from NERL to GPA to enable the vectoring and sequencing of traffic. Given that Euchanhead is under the extended GPA runway centreline, it is likely that NERL only control the airspace from 6,000ft above Euchanhead.

4.5.3. Cyrrus understands that NATS' units optimally require circa 2,000ft of additional PSR coverage below the base of NERL controlled airspace to provide a safety buffer for controllers. This means that PSRs must be capable of detecting airborne targets at a minimum altitude of either 3,500ft or 4,000ft over Euchanhead.

4.5.4. Candidate radars for infill coverage over Euchanhead are Cumbernauld PSR, Glasgow PSR and possibly Glasgow Terma PSR.

4.6. Potential Infill Radars – Cumbernauld PSR

4.6.1. The Euchanhead turbines are between 67.5km (36.4NM) and 74.9km (40.4NM) from Cumbernauld PSR. The magenta shading in Figure 23 illustrates the RLoS coverage for Cumbernauld PSR at an altitude of 3,500ft.



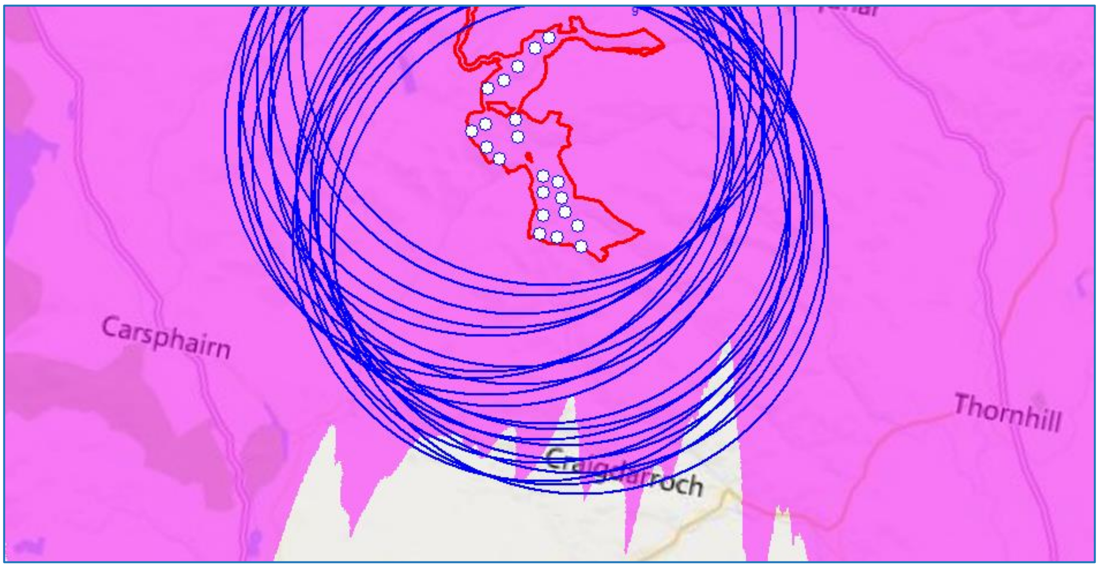
Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 23: Cumbernauld PSR RLoS at 3,500ft AMSL

4.6.2. It can be seen in Figure 23 that Cumbernauld PSR can provide radar coverage down to an altitude of 3,500ft in the vicinity of the Euchanhead turbines.

4.6.3. Historically, there has been a NERL requirement that infill coverage is extended to include a 5NM buffer on all the mitigated wind turbines. It is not known how strictly this requirement is currently being applied.

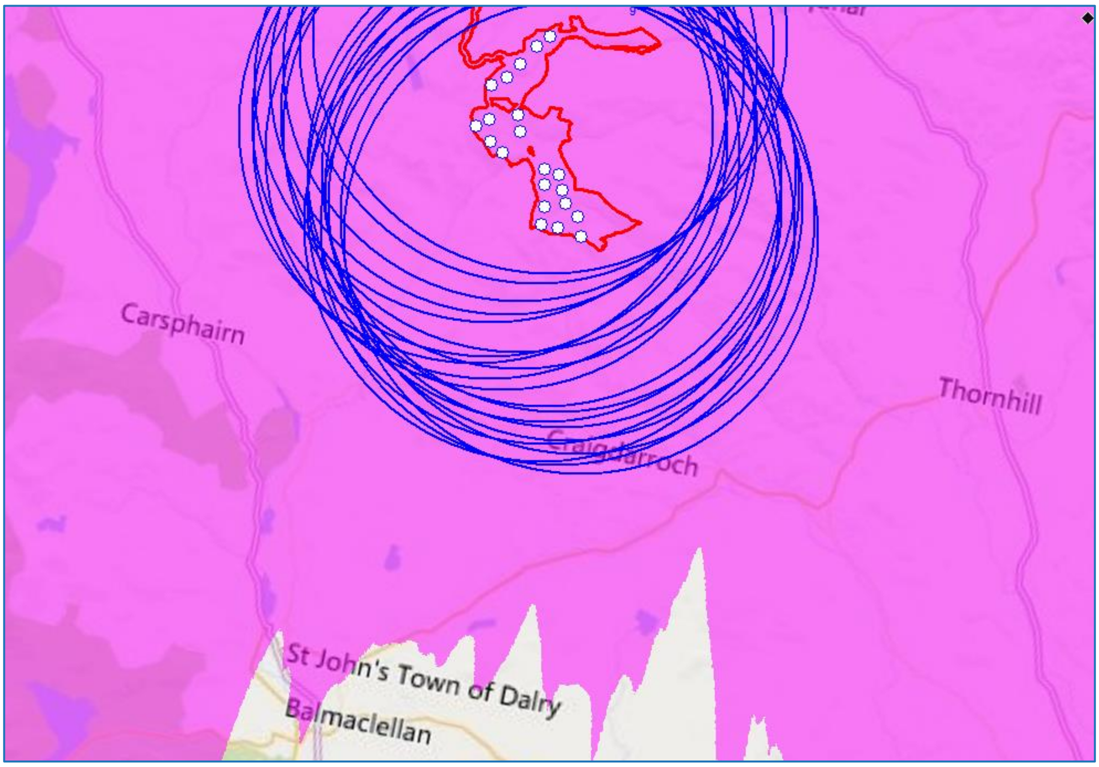
4.6.4. The zoomed view of the Cumbernauld PSR 3,500ft coverage in Figure 24 includes 5NM circles centred on each Euchanhead turbine to illustrate where the buffer may be required to extend to.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 24: Cumbernauld PSR RLoS at 3,500ft AMSL – zoomed

4.6.5. As can be seen, coverage at altitude 3,500ft does not quite extend to 5NM south of the turbines. Figure 25 shows that the 5NM buffer is achieved for coverage at 4,000ft AMSL.



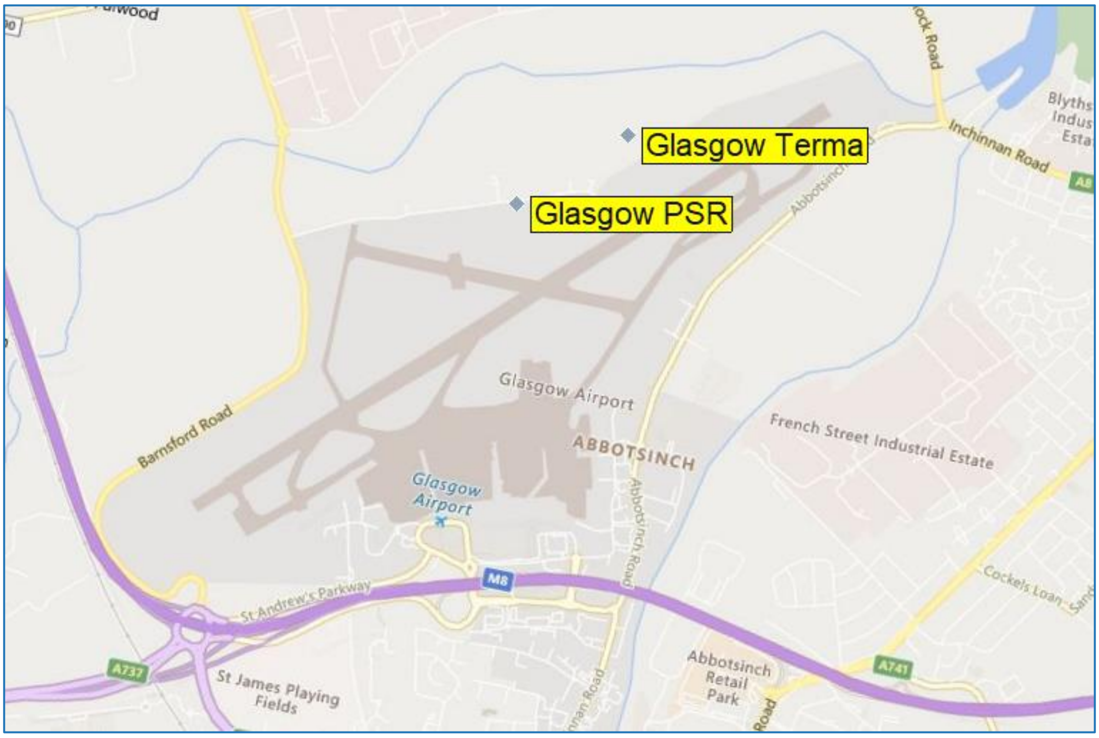
Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 25: Cumbernauld PSR RLoS at 4,000ft AMSL – zoomed

4.6.6. Notwithstanding the 5NM buffer requirement, Cumbernauld PSR can provide the minimum 3,500ft AMSL infill coverage over the Euchanhead turbines. If the 5NM buffer is enforced than minimum coverage is 4,000ft AMSL which satisfies a NERL base of controlled airspace of 6,000ft AMSL.

4.7. Potential Infill Radars – Glasgow PSR and Glasgow Terma

4.7.1. The locations of the Glasgow PSR and Glasgow Terma are shown in Figure 26.

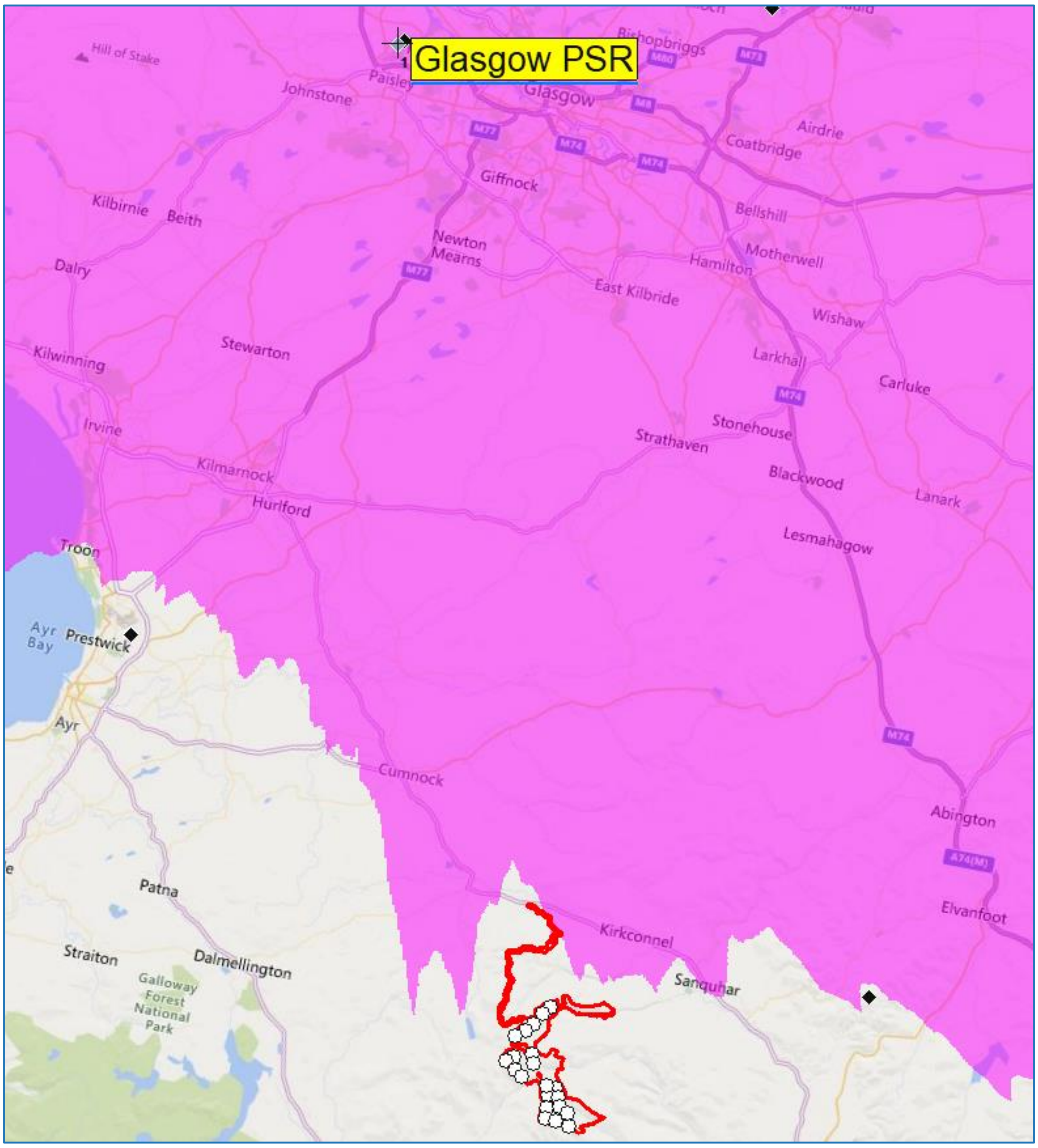


Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 26: Locations of Glasgow PSR and Glasgow Terma

4.7.2. The Euchanhead turbines are between 64.4km (34.8NM) and 72.4km (39.1NM) from the Glasgow radars.

4.7.3. The magenta shading in Figure 27 illustrates the RLoS coverage for Glasgow PSR at an altitude of 3,500ft.

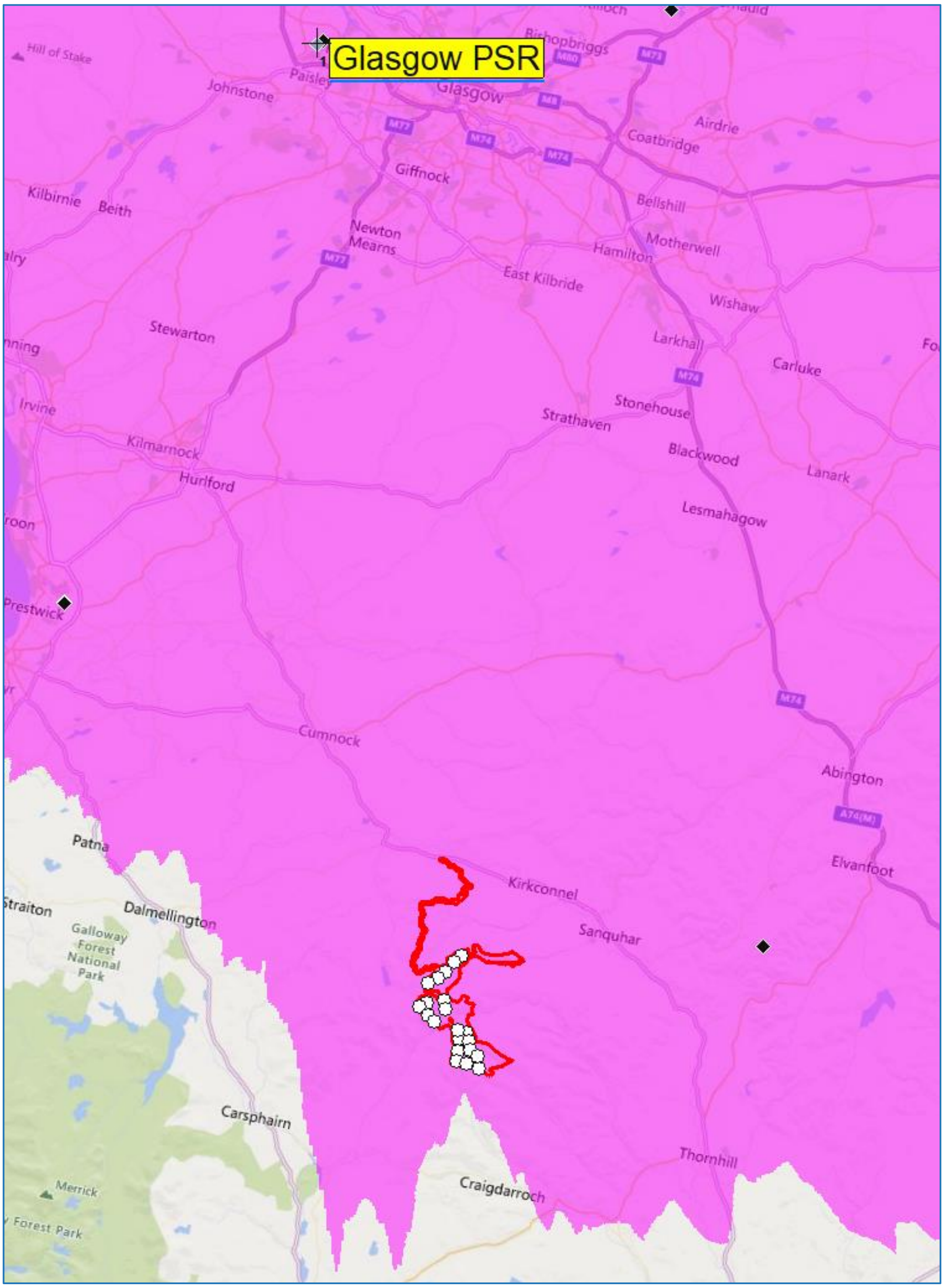


Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 27: Glasgow PSR RLoS at 3,500ft AMSL

4.7.4. It can be seen that Glasgow PSR cannot provide radar coverage down to an altitude of 3,500ft in the vicinity of the Euchanhead turbines.

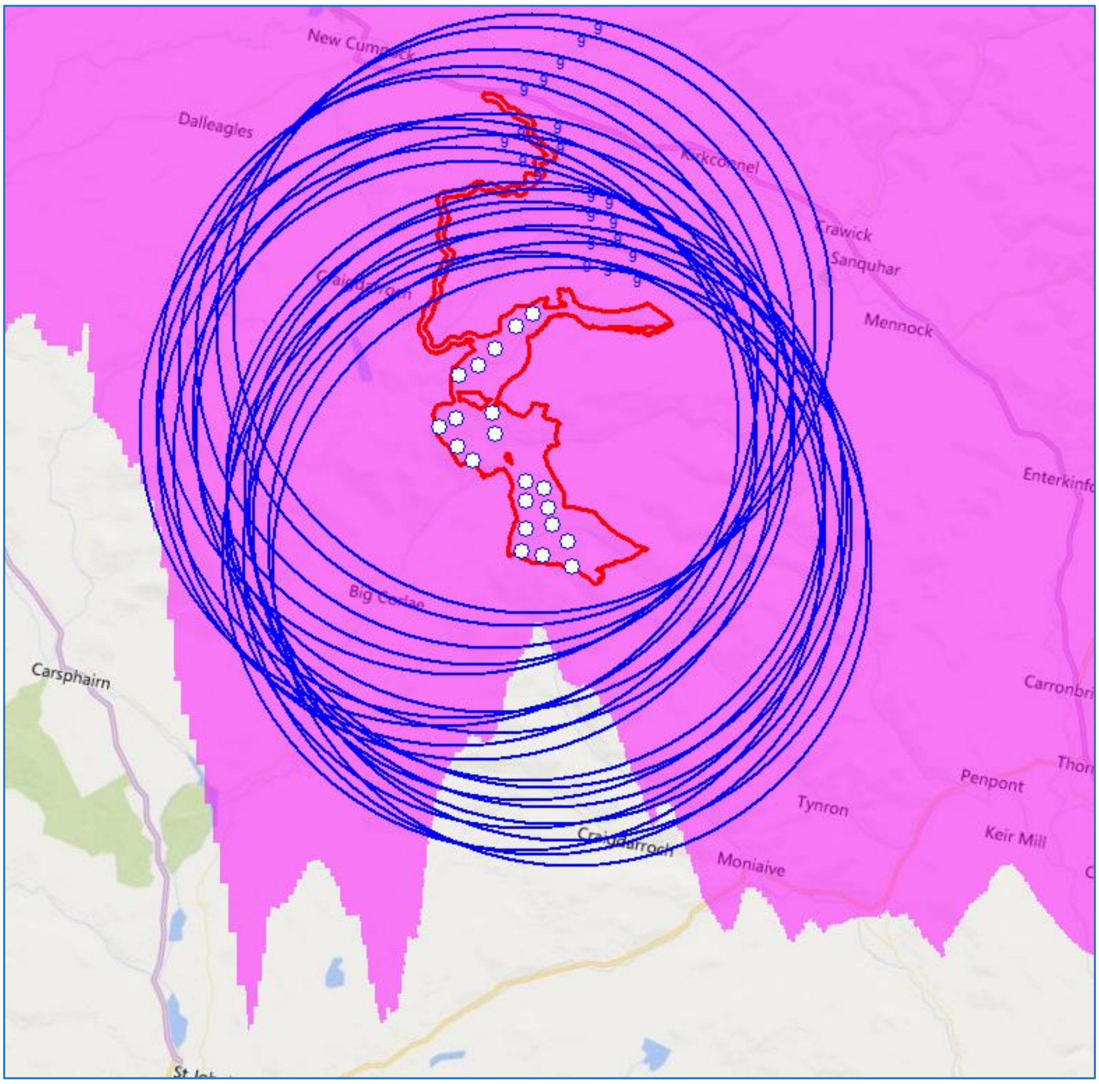
4.7.5. The base of Glasgow PSR coverage over the Euchanhead turbines is 5,000ft AMSL, as shown by the magenta shading in Figure 28.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 28: Glasgow PSR RLoS at 5,000ft AMSL

4.7.6. The zoomed view of the Glasgow PSR 5,000ft coverage in Figure 29 includes range rings centred on each turbine to illustrate where the 5NM buffer may be required to extend to.

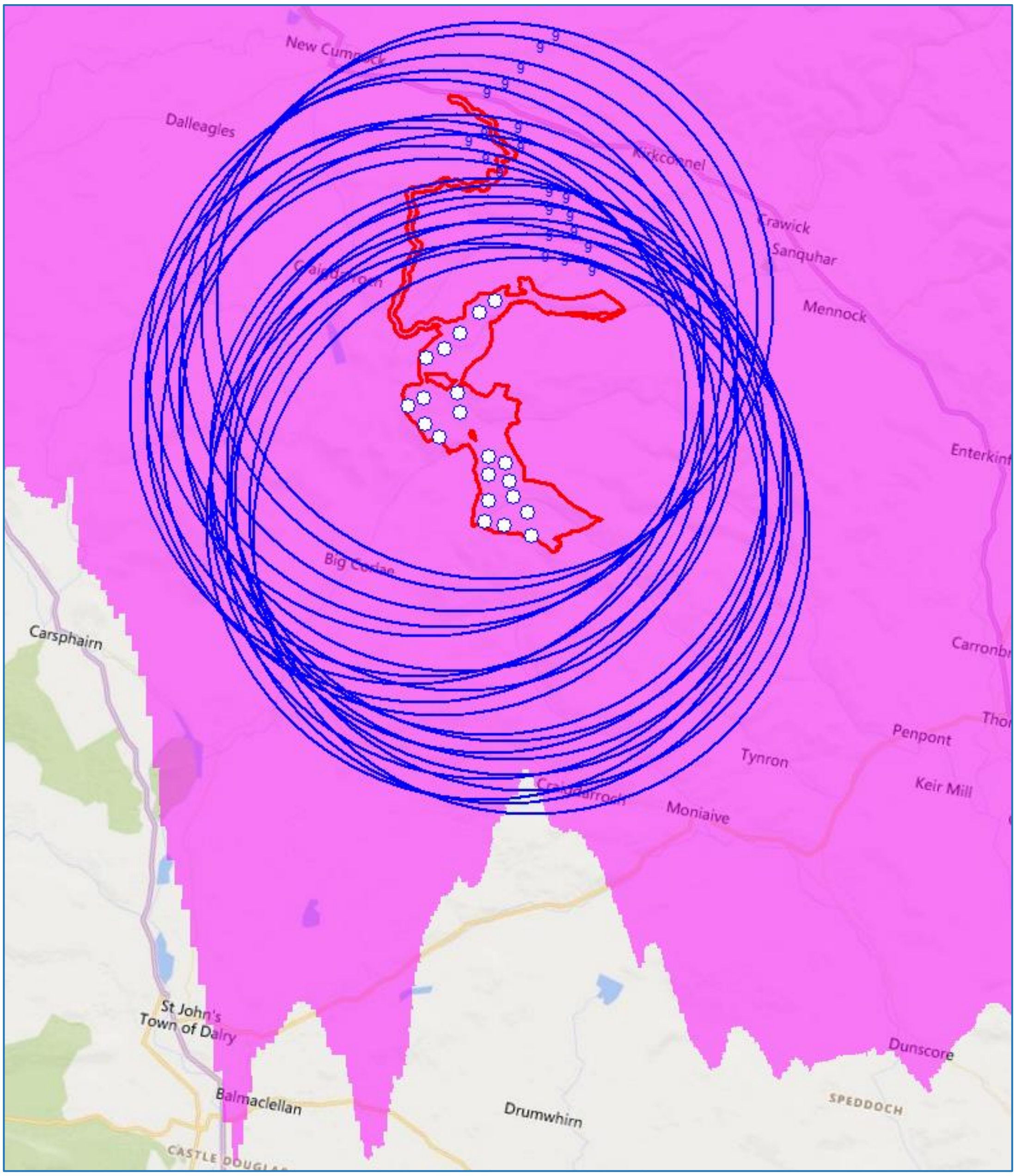


Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 29: Glasgow PSR RLoS at 5,000ft AMSL – zoomed

4.7.7. Glasgow PSR coverage 5,000ft AMSL does not quite extend to 5NM south of the turbines.

4.7.8. Figure 30 shows that the 5NM buffer is mostly achieved for coverage at 5,500ft AMSL.

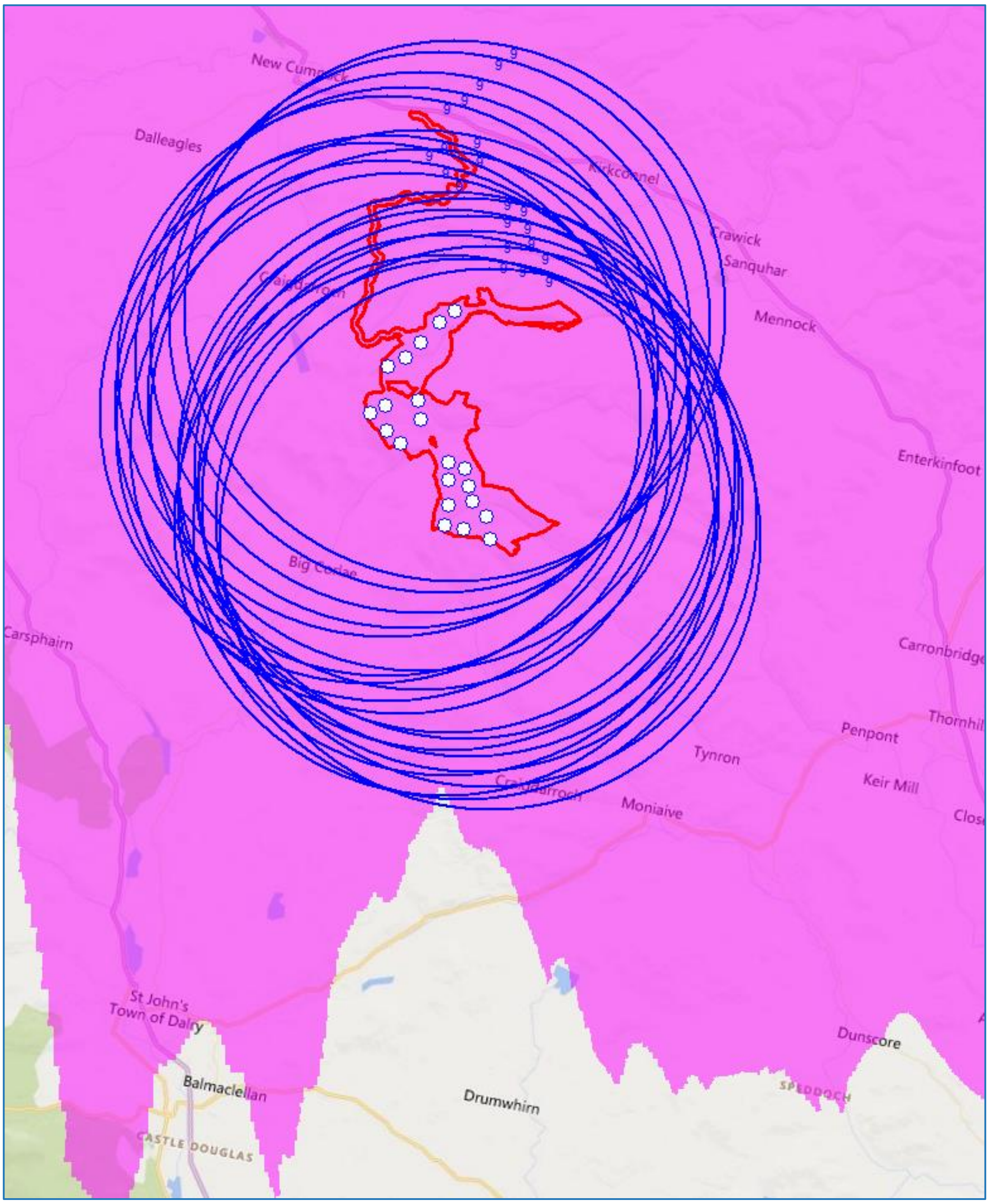


Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 30: Glasgow PSR RLoS at 5,500ft AMSL – zoomed

4.7.9. The Glasgow Terma is sited in close proximity to the Glasgow PSR and thus has very similar RLoS coverage performance.

4.7.10. The magenta shading in Figure 31 shows the Glasgow Terma RLoS coverage at 5,500ft AMSL over the Euchanhead turbines.



Microsoft® Bing™ screen shot reprinted with permission from Microsoft Corporation

Figure 31: Glasgow Terma RLoS at 5,500ft AMSL – zoomed

4.7.11. Notwithstanding the 5NM buffer requirement, Glasgow PSR or Terma can provide the 5,000ft AMSL infill coverage over the Euchanhead turbines. If the 5NM buffer is enforced than minimum coverage is 5,500ft AMSL which satisfies a NERL base of controlled airspace of 7,500ft AMSL.

4.7.12. The range of Euchanhead from the Glasgow Terma may be towards the limit of its coverage performance when considering all possible weather conditions.

5. Airspace Analysis

5.1. Introduction

5.1.1. This assessment is a review of potential impacts on aviation in the designated areas of Euchanhead. Information has been referenced from the UK Aeronautical Information Publication (AIP), available online from source, and is therefore the latest information available. Additional information has been sourced from UK Civil Aviation Authority (CAA) and MOD publications, as appropriate.

5.1.2. 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 Euchanhead Renewable Energy Development 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 1013.2hPa. 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 5,500ft. Refer UK AIP ENR 1.7 Altimeter Setting Procedures.

5.4. Airspace and Glasgow Prestwick Airport

5.4.1. Euchanhead is situated within Class G (uncontrolled) airspace beneath the Class D (controlled airspace) Scottish Terminal Control Area (TMA) with a base of 5,500ft AMSL and a Class D volume of airspace associated with Air Traffic Service (ATS) Route Z250. Euchanhead sits below the waypoint SUMIN, a Significant Point on ATS Route Z250. The base level of Z250 to the west of SUMIN is altitude 5,500ft and to the east is FL125 (approximately 12,500ft AMSL).

5.4.2. Waypoint SUMIN is used as a Holding position for arriving aircraft. Aircraft may need to hold overhead position SUMIN at levels between altitude 6,000ft and FL90.

5.4.3. The Scottish TMA is controlled by NERL from the en-route centre located in Prestwick. Control of the TMA airspace in the vicinity of GPA from 5,500ft to 6,000ft AMSL is delegated from NERL to GPA to enable the airport to vector and sequence traffic. GPA has a Designated Operating Coverage (DOC) of 42 Nautical Miles (NM) for its radar services. Within this DOC outside controlled airspace GPA provides advisory and information services to aircraft transiting or operating to and from GPA. Aircraft in uncontrolled airspace are not obliged to contact Air Traffic Control (ATC).

5.4.4. The Scottish TMA 2 is Class D Airspace (controlled) and is defined as a Transponder Mandatory Zone (TMZ) between 6,000ft and F100 in the UK AIP ENR 2.1. Note 2 of the airspace definition states the following: *"Within the lateral boundaries of Scottish TMA 2 between 6000 FT ALT and FL 100 is a TMZ (Transponder Mandatory Zone). Carriage and operation of a transponder with Mode A code and Mode C altitude (or equivalent Mode S) is mandatory."*

5.4.5. Euchanhead is located under the southern part of the Scottish TMA and east of GPA airspace. The elevation of the highest proposed turbine extends to 843m (circa 2,770ft) Above Ordnance Datum (AOD) and as such, does not penetrate the controlled airspace with over 2,500ft above the highest obstacle. The proposed turbines at Euchanhead are depicted in red in Figure 32 along with the surrounding airspace.

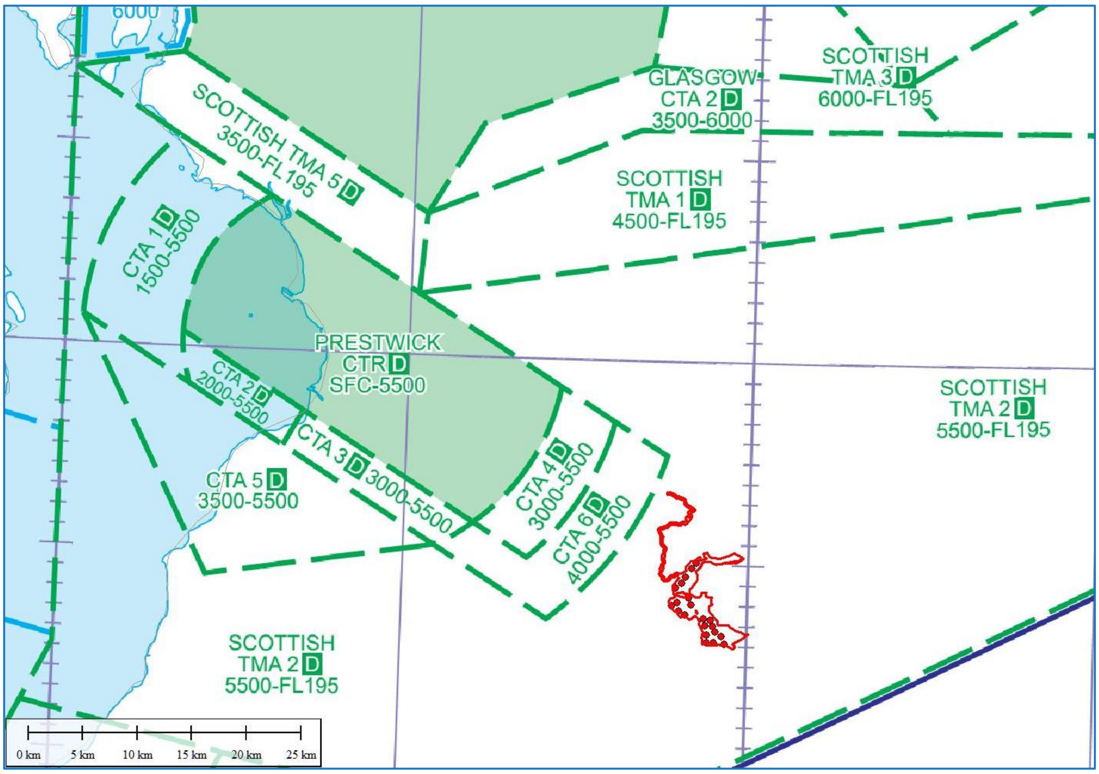


Chart reproduced with the permission of NATS (Services) Limited.

Figure 32: Airspace Overview

5.4.6. The proposed Euchanhead site is approximately 20NM south-east of GPA.

5.5. Inbound and Outbound Aircraft – GPA

5.5.1. GPA has a standing agreement with NERL that all traffic inbound via the airways structure will be handed to GPA descending to FL70 (approximately 7,000ft AMSL) and routing using Standard Arrival Routes (STARs) to either Turnberry (TRN) or the waypoint SUMIN unless otherwise coordinated. Procedures for inbound aircraft are detailed in the AIP in section EGPK AD 2.22 Flight Procedures. Figure 33 is an extract from the AIP detailing the routing requirements.

5.5.2. Traffic from the west is generally routed towards TRN and these routes are well clear of Euchanhead.

a. The Standard Arrival Routes for arrivals from the ATS route system are as follows, and are detailed at AD 2-EGPK-7-1

Approach from	Via	Route
Southeast and South	N601/UN601, UN590	ASLIB - ENIPI - direct TRN For Runway 30 arrivals, tactical routing to SUMIN may be given.
Southwest	P600	BLACA - P600 - TRN

b. Arrival routes from all other directions are as follows:

Approach from	Via	Route
North and Northeast	P600	Direct to TRN or SUMIN REP by Scottish ACC, or transferred to Glasgow Approach for transit of the Glasgow CTR/CTA and/or Scottish TMA.
East	Y96, L983	Tactical routing to TRN or SUMIN by Scottish ACC.
West and Northwest	N562	Routed direct to TRN by Scottish ACC.

AIP Extract reproduced with the permission of NATS (Services) Limited.

Figure 33: Procedures for Inbound Aircraft

5.5.3. The extracts in Figure 34 and Figure 35 indicate the location of Euchanhead (depicted in red) in relation to the GPA STARs and Approach Transitions. Given the relatively low traffic figures for GPA, inbound aircraft are unlikely to route or hold at position SUMIN due to capacity constraints.

5.5.4. Position SUMIN is contained within airspace designated as a TMZ and therefore should not be impacted by any potential impact to PSR as the associated SSR should more than adequately provide the mitigation required.

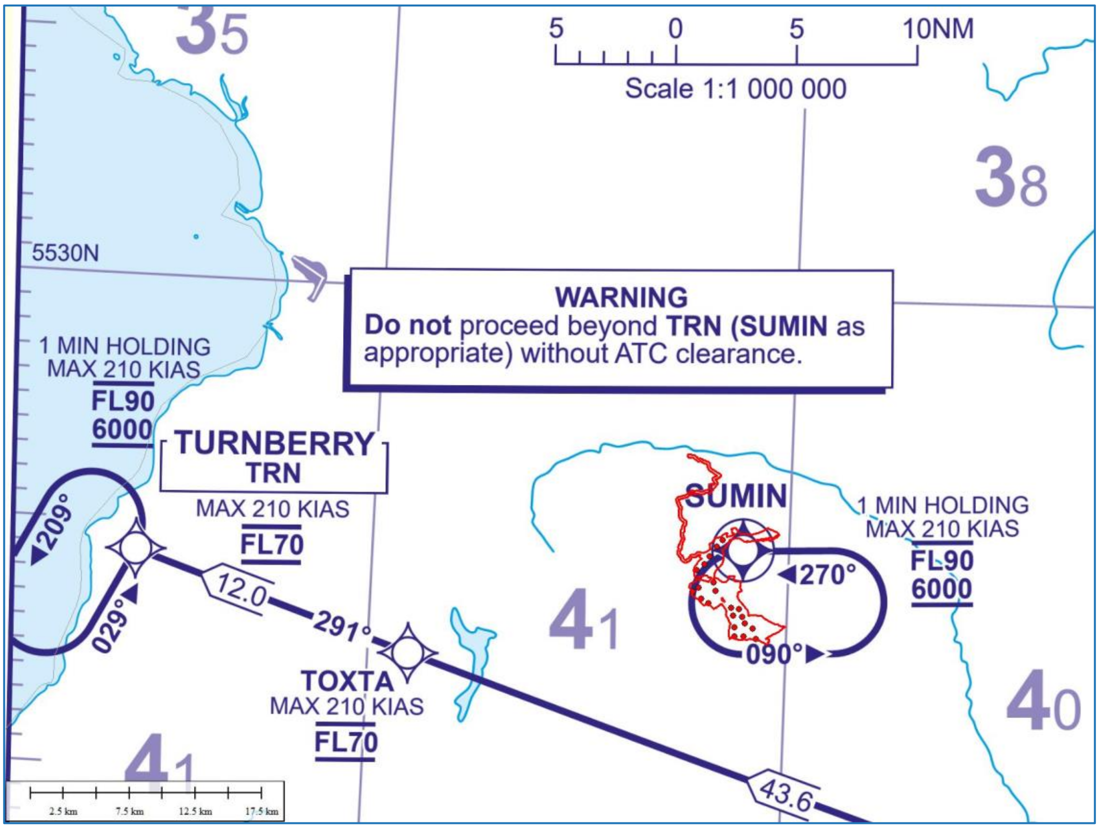


Chart reproduced with the permission of NATS (Services) Limited.

Figure 34: RNAV5 Standard Arrival Chart AD 2-EGPK-7-2

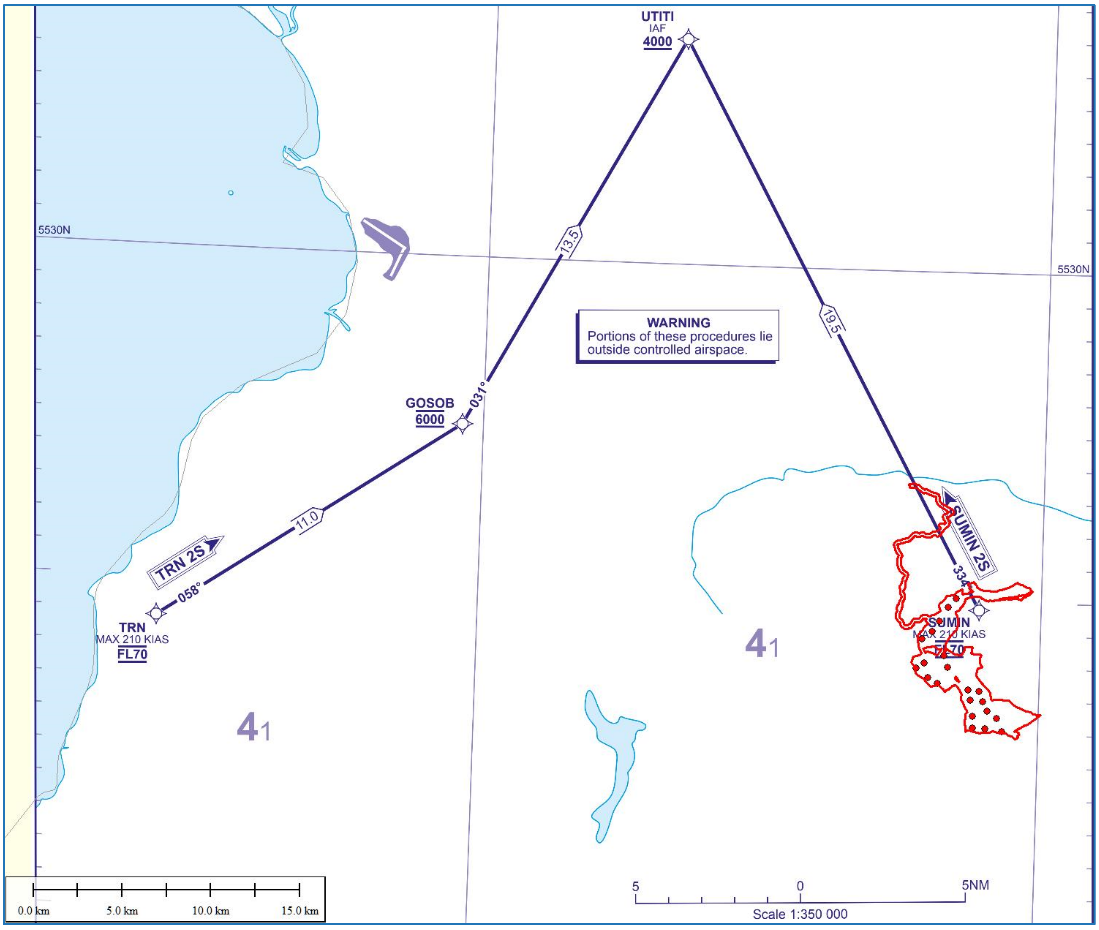


Chart reproduced with the permission of NATS (Services) Limited.

Figure 35: RNAV1 Approach Transitions Chart AD 2-EGPK-7-4

5.5.5. GPA has a number of Standard Instrument Departures (SIDs) for traffic departing via the airways structure. The tracks of all the SIDs are clear of Euchanhead. For other departing traffic the routine coordination is for GPA to clear the aircraft to 6,000ft AMSL then transfer it to NERL once on its agreed heading and clear of other traffic. Given the climb rates of most modern aircraft even traffic heading straight towards Euchanhead will be well above 6,000ft and working NERL before overflying any potential turbine clutter on GPA radars.

5.5.6. Figure 36 provides an extract of the SIDs from the AIP and indicates the SID routing via SUMIN. Only departures from GPA wishing to route Y96 via Z250 will use this departure route (highlighted in bold below). Part 3 of Section EGPK AD 2.22 Flight Procedures is duplicated below which defines the procedures for Outbound Aircraft:

"3 PROCEDURES FOR OUTBOUND AIRCRAFT

a. Standard Instrument Departures from Prestwick are as follows (see AD 2-EGPK-6-1/2):

- *P600 via TRN*
- *N560 via TRN to GOW*
- *L602 via TRN to GOW*
- *UL612 North via TRN to GOW*
- *T256/UT256 departing Runway 30, LUCCO Z248 OSMEG T256 DCS*
- *T256/UT256 departing Runway 12, SUDBY Z249 OSMEG T256 DCS*

- *Y96 departing Runway 30, LUCCO Z250 HAVEN*
- ***Y96 departing Runway 12, SUMIN Z250 HAVEN***
- *N562 departing Runway 30, DAUNT Z246 HERON*
- *N562 departing Runway 12, OKNOB Z247 HERON"*

5.5.7. As the AIP extract shows, not all outbound aircraft are reliant on routing via SUMIN.

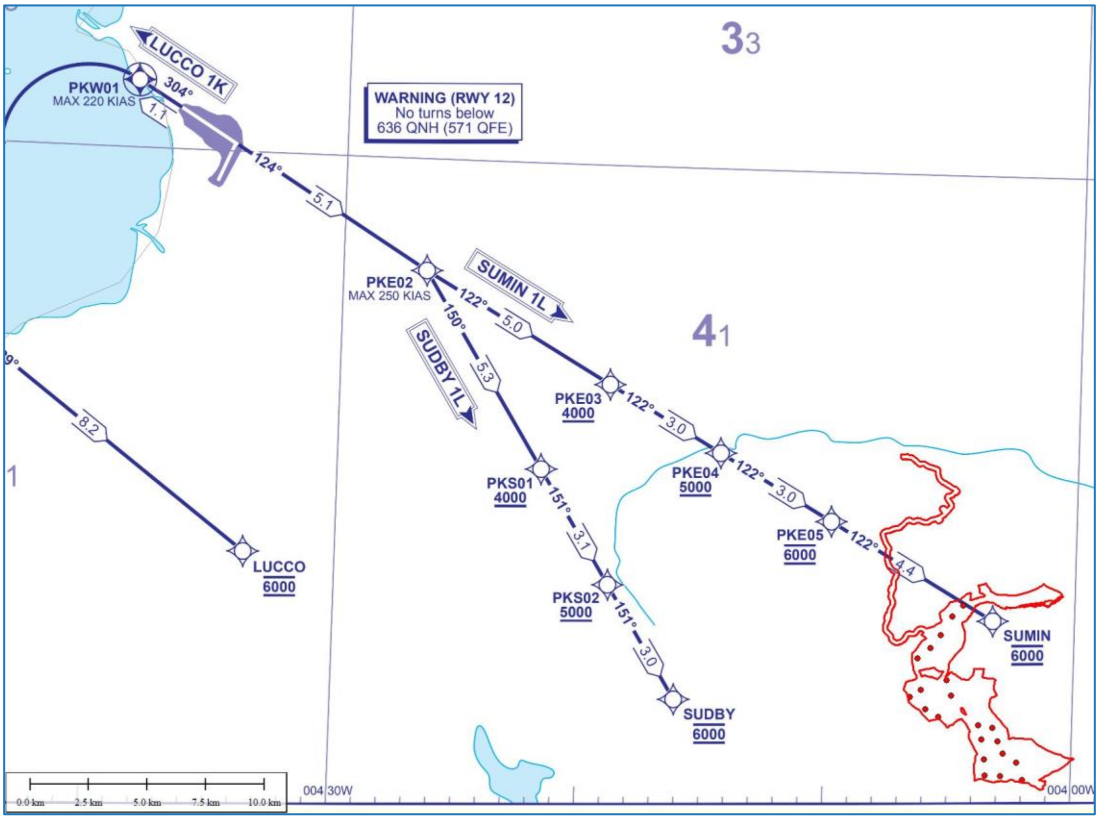


Chart reproduced with the permission of NATS (Services) Limited.

Figure 36: RNAV1 Standard Departure Chart AD 2-EGPK-6-1

5.5.8. Outbound aircraft, from GPA routing via SUMIN are restricted to cross SUMIN at a minimum altitude of 6,000ft. ATS Route Z250 then turns to the north-east to join Y96 at HAVEN.

5.5.9. Figure 37 highlights the two ATS routes (Z250 and Y96) in relation to the Airport and Euchanhead (in red).

5.5.10. NATS En-Route (NERL) provide Air Traffic Services (ATS) to aircraft departing and approaching GPA.

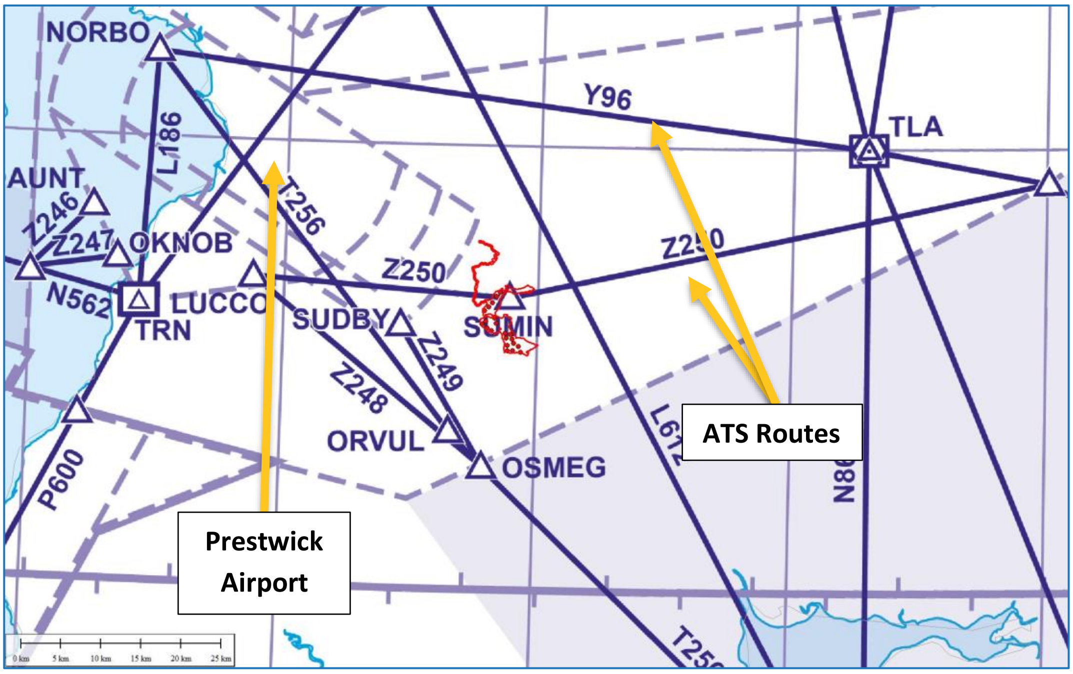


Chart reproduced with the permission of NATS (Services) Limited.

Figure 37: Lower ATS Routes ENR 6-69

5.5.11. Euchanhead is more than 5NM beyond the south-eastern extremity of the GPA ATC Surveillance Minimum Altitude Chart (ATCSMAC), as shown in Figure 38, and will therefore not result in changes to this chart.

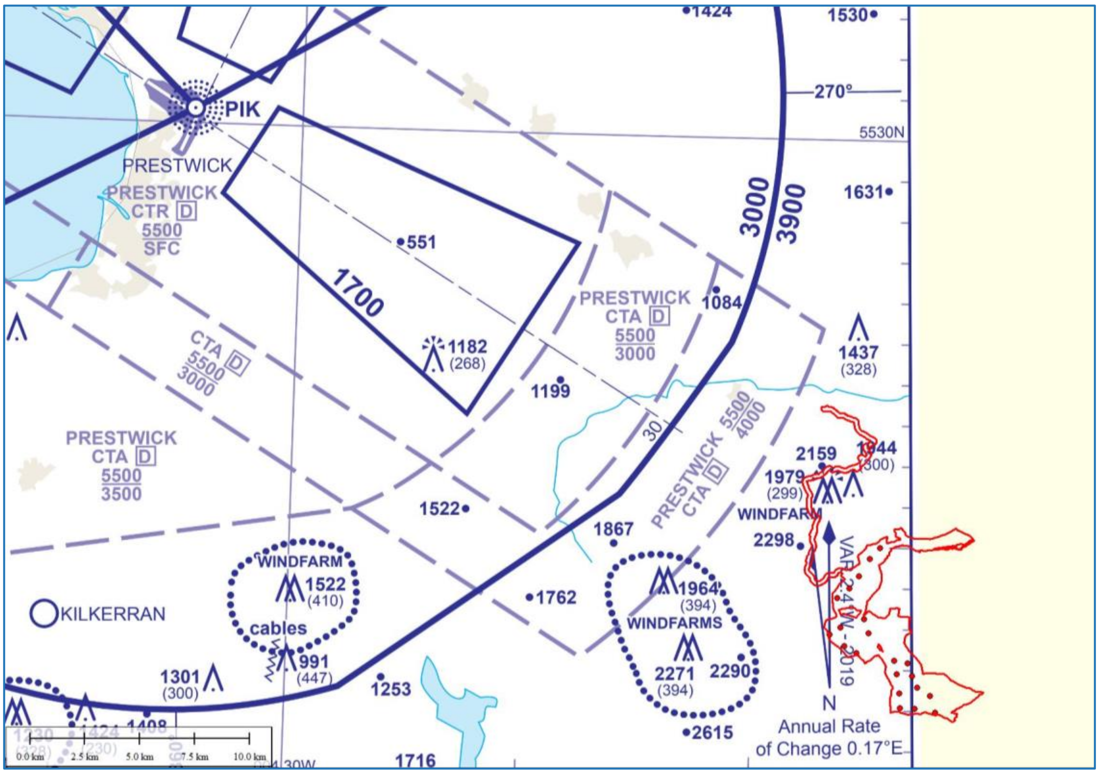


Chart reproduced with the permission of NATS (Services) Limited.

Figure 38: GPA ATCSMAC AD 2-EGPK-5-1

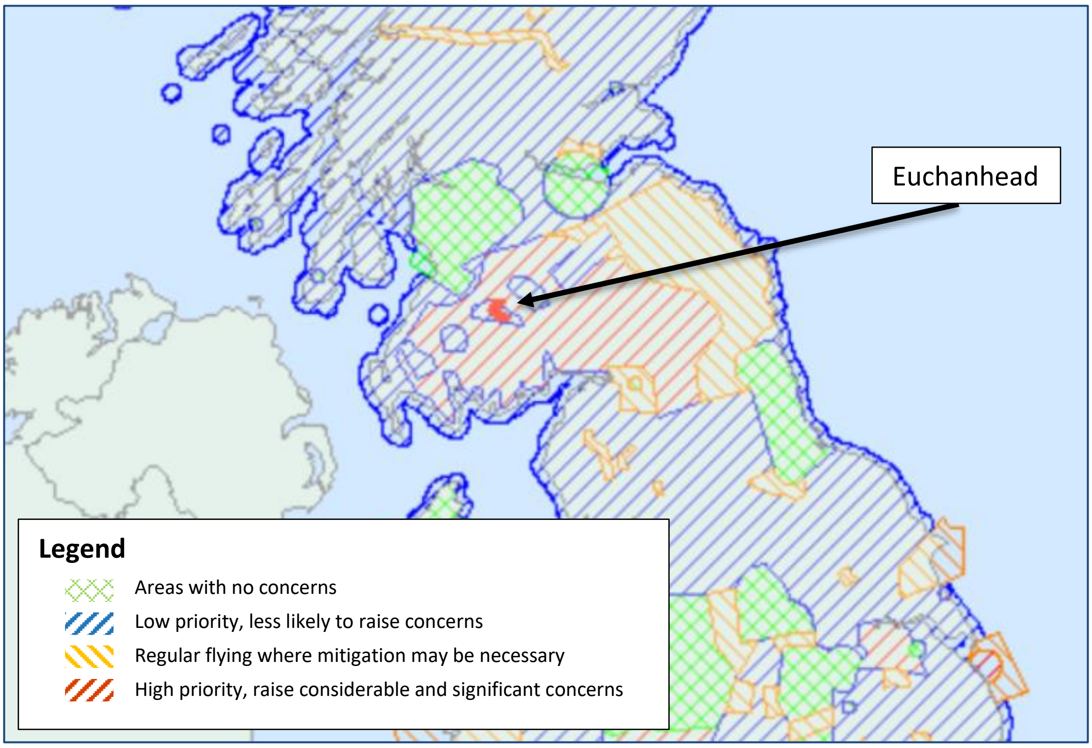
5.6. Other Airspace Users

5.6.1. In addition to the commercial aircraft operating to and from GPA, the MOD and General Aviation (GA) communities must be considered.

5.6.2. The main risk posed by GA traffic transiting underneath controlled airspace is from infringements into controlled airspace. As previously mentioned, traffic in uncontrolled airspace is not obliged to contact ATC and, in this area, does not have to be carrying a transponder. To the GPA controller a transit aircraft may display as a primary only contact. Clutter from the proposed Development would effectively mask any transit traffic that may prove to be a threat to traffic being provided with a service from GPA.

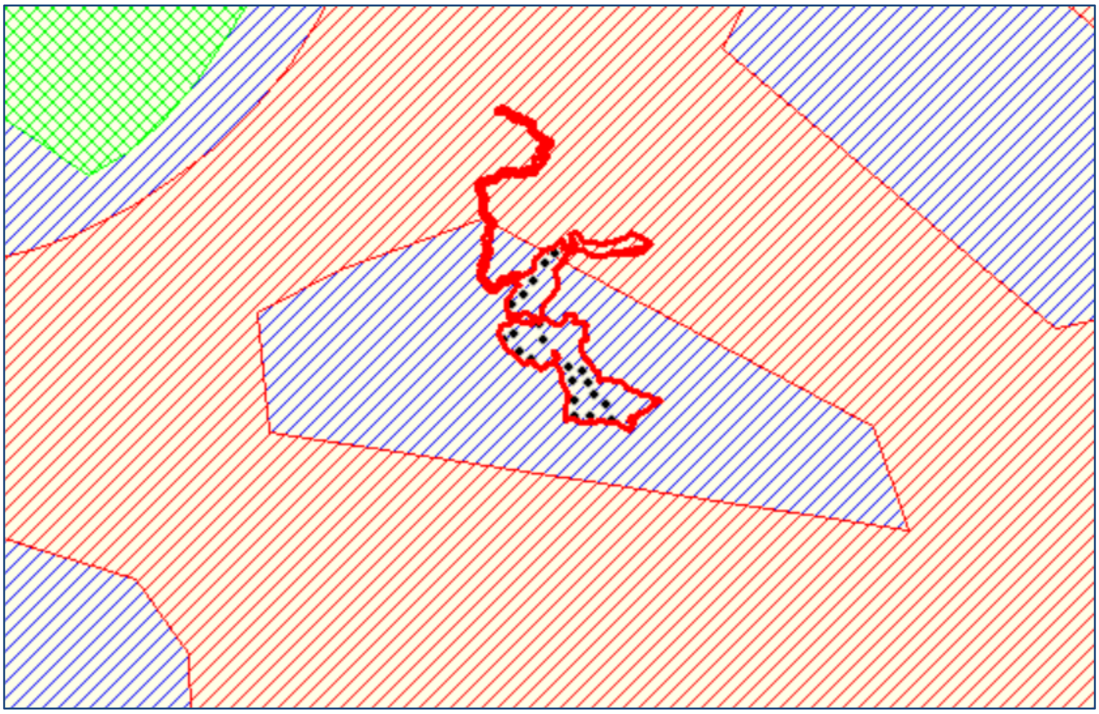
5.6.3. As demonstrated above, traffic inside controlled airspace should be far enough away from Euchanhead that any 'pop up' traffic that may have been hidden by the proposed Development should be able to be spotted by the controller in sufficient time to take any necessary action. For traffic being provided with a service outside controlled airspace the controller has the ability to limit the service in the vicinity of the proposed Development.

5.6.4. Euchanhead is predominantly located within an MOD "blue" low priority consultation zone with a small defined area within a 'red' zone. Figure 39 indicates an overview of the MOD Low Flying Consultation Zones while Figure 40 indicates a zoomed in area around Euchanhead. The area extending into the 'red' zone contains a single turbine just across the boundary line.



Map reference DE090071, V7 dated 07 October 2011.
MOD Safeguarding Data is © Crown Copyright, Defence Infrastructure Organisation 2020

Figure 39: MOD Low Flying Consultation Zones map



Map reference DE090071, V7 dated 07 October 2011.
MOD Safeguarding Data is © Crown Copyright, Defence Infrastructure Organisation 2020
Figure 40: Zoomed in MOD Low Flying Consultation Zones map

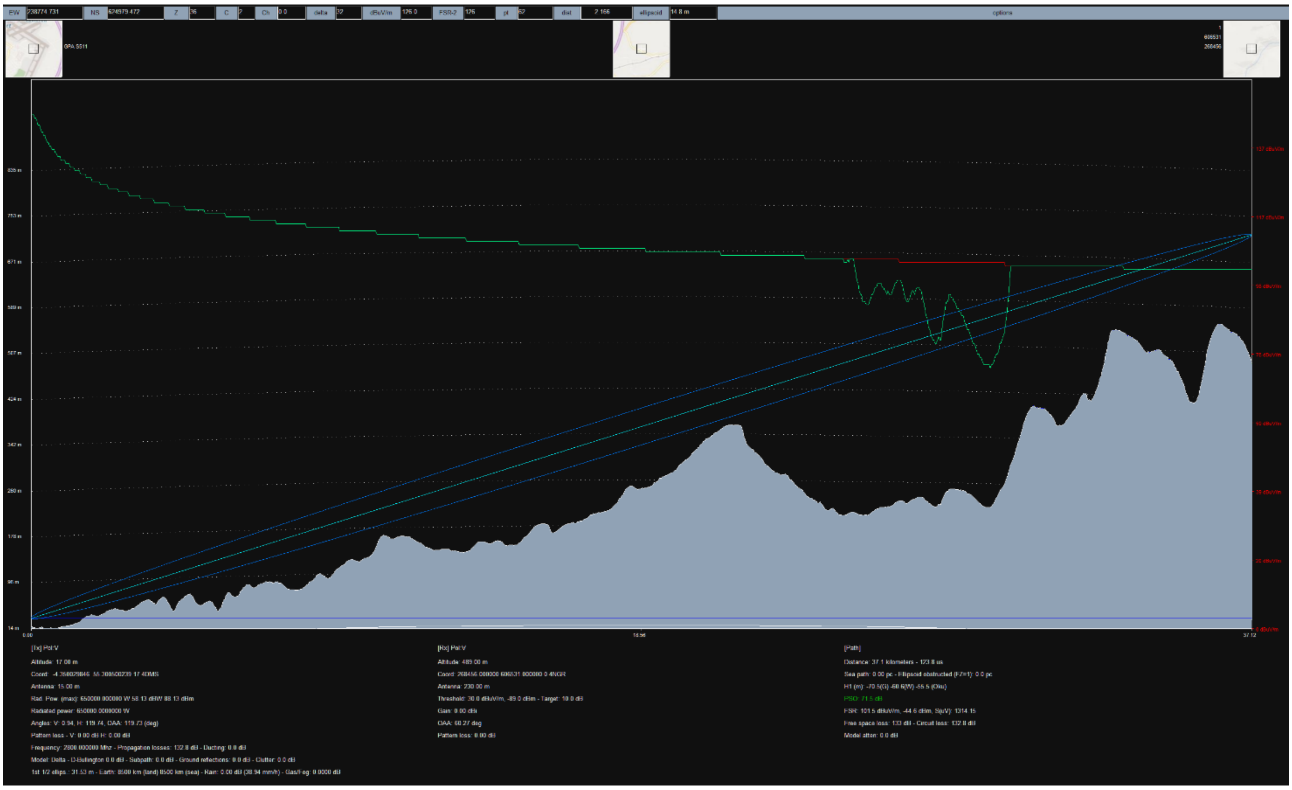
5.6.5. All but one of the Euchanhead turbines fall within the MOD 'blue' zone, this indicates an area of low priority and less likely to raise concerns. The single turbine that is within the "red" zone is classed as a high priority military low flying area, likely to raise considerable and significant concerns.

5.6.6. The MOD has indicated in writing, referenced DIO10047478 and dated 05 March 2020, that Euchanhead will occupy Low Flying Area 14 (in fact Low Flying Area 20T), presenting a potential obstruction hazard to military low flying training activities, but does not expand into detail how many turbines impact the respective zones. Notwithstanding, the letter does state that mitigation, in the form of MOD accredited aviation safety lighting in accordance with the relevant regulations, would address any impact.

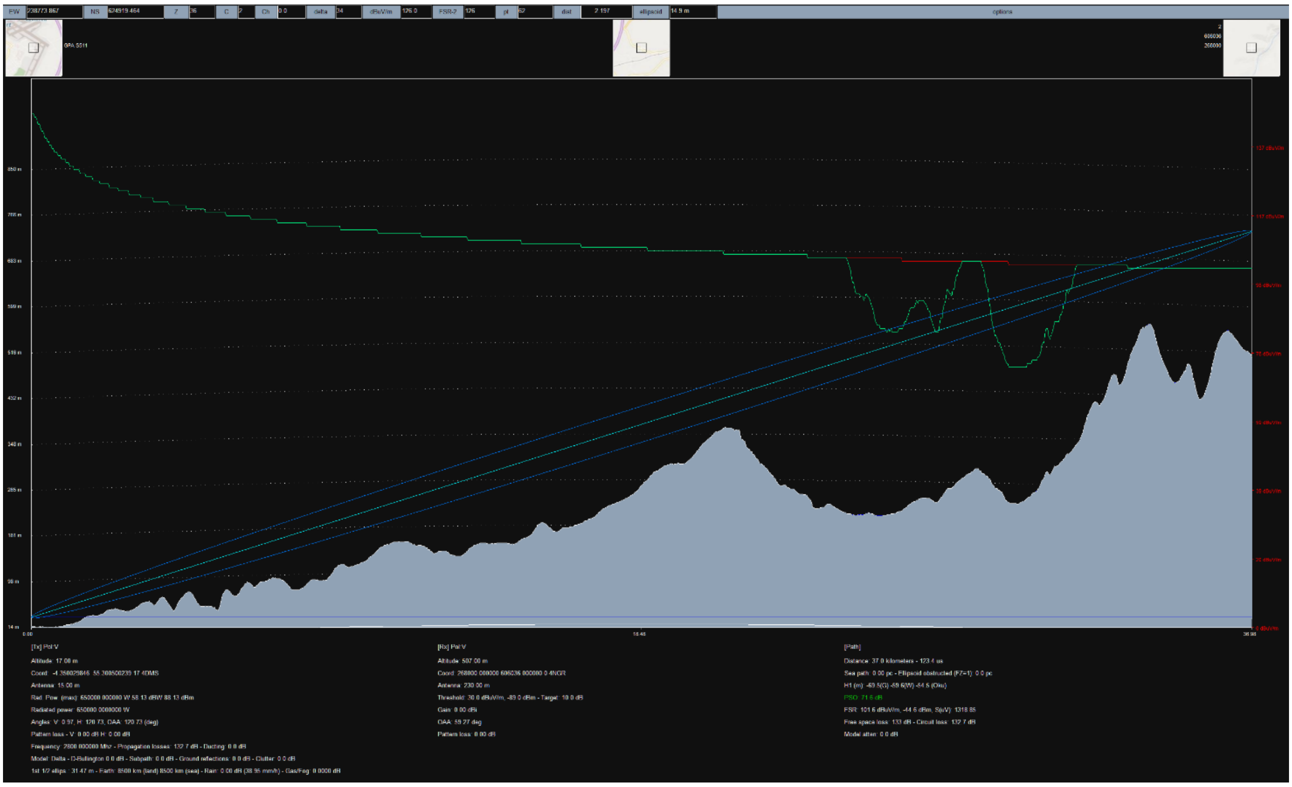
5.6.7. Volumes of controlled and restricted airspace can result in the channelling or funnelling of such traffic around structures. In this instance, there are no Danger Areas in the vicinity to create a funnelling effect as there is sufficient uncontrolled airspace above the proposed wind turbines to safely transit this area under Visual Flight Rules (VFR) subject to the applicable 'Rules of the Air' being complied with.

A. Annex A – GPA S511 PSR Path Profiles

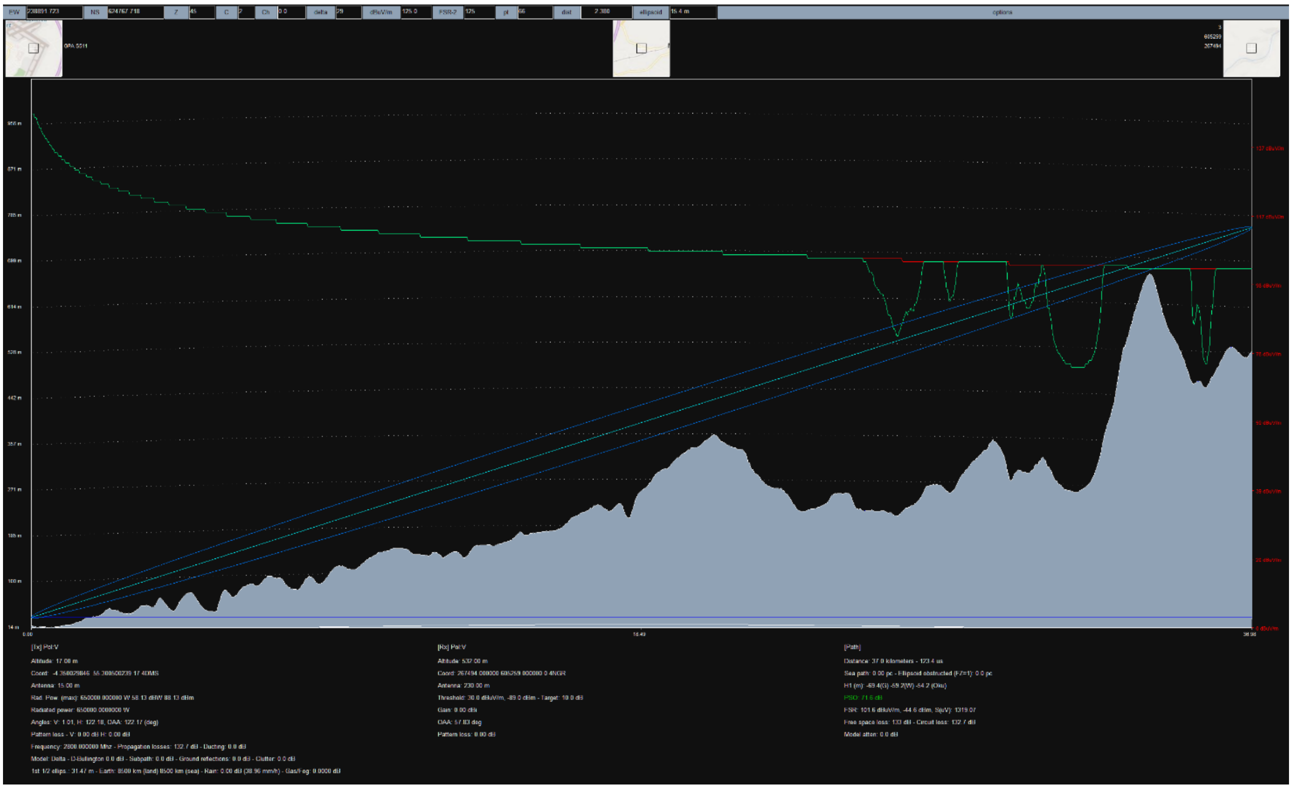
A.1. Turbine 1



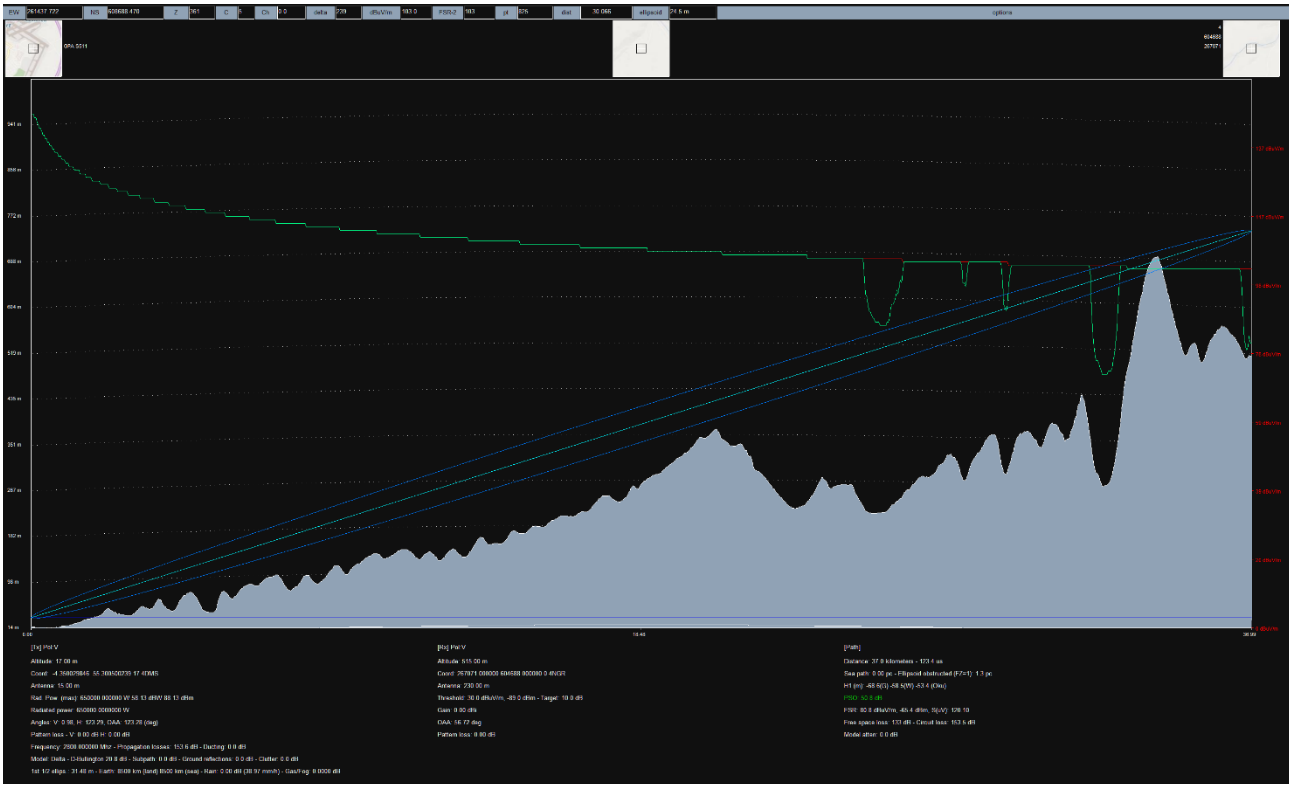
A.2. Turbine 2



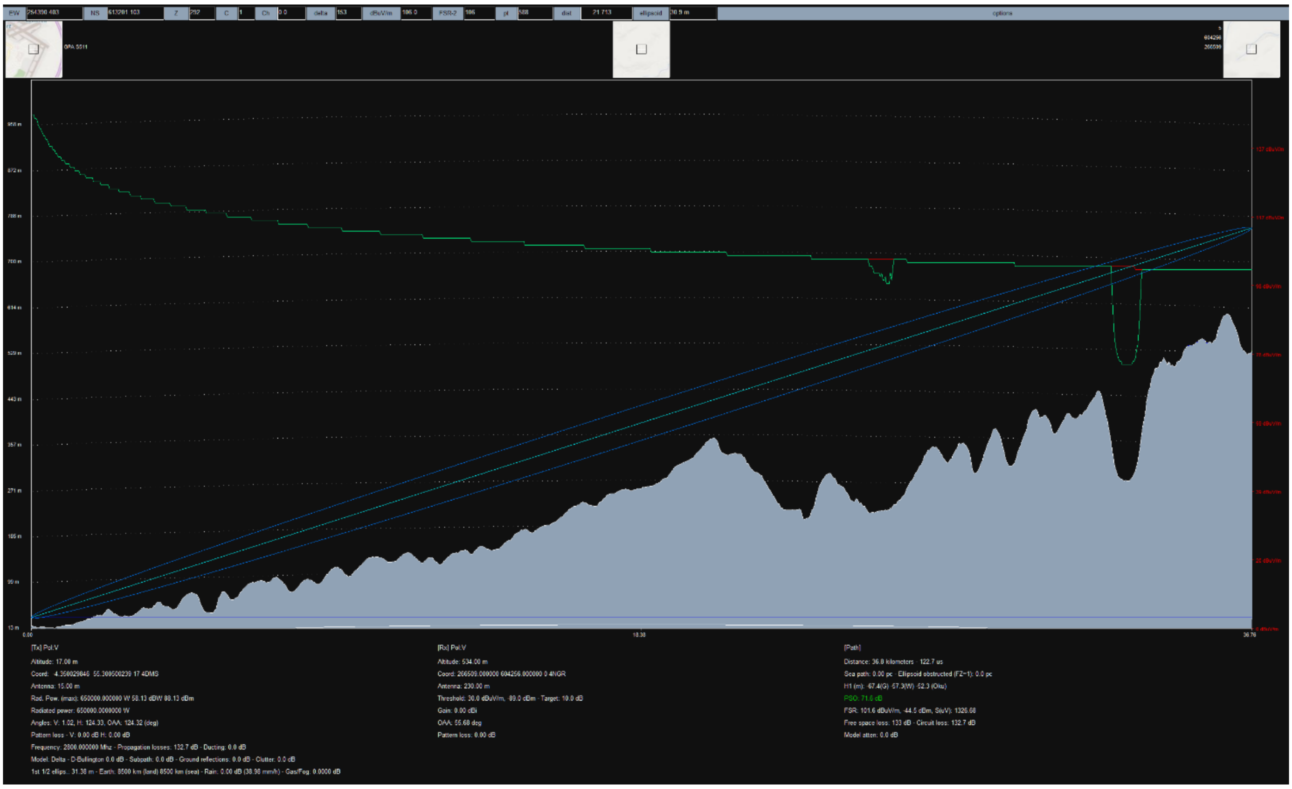
A.3. Turbine 3



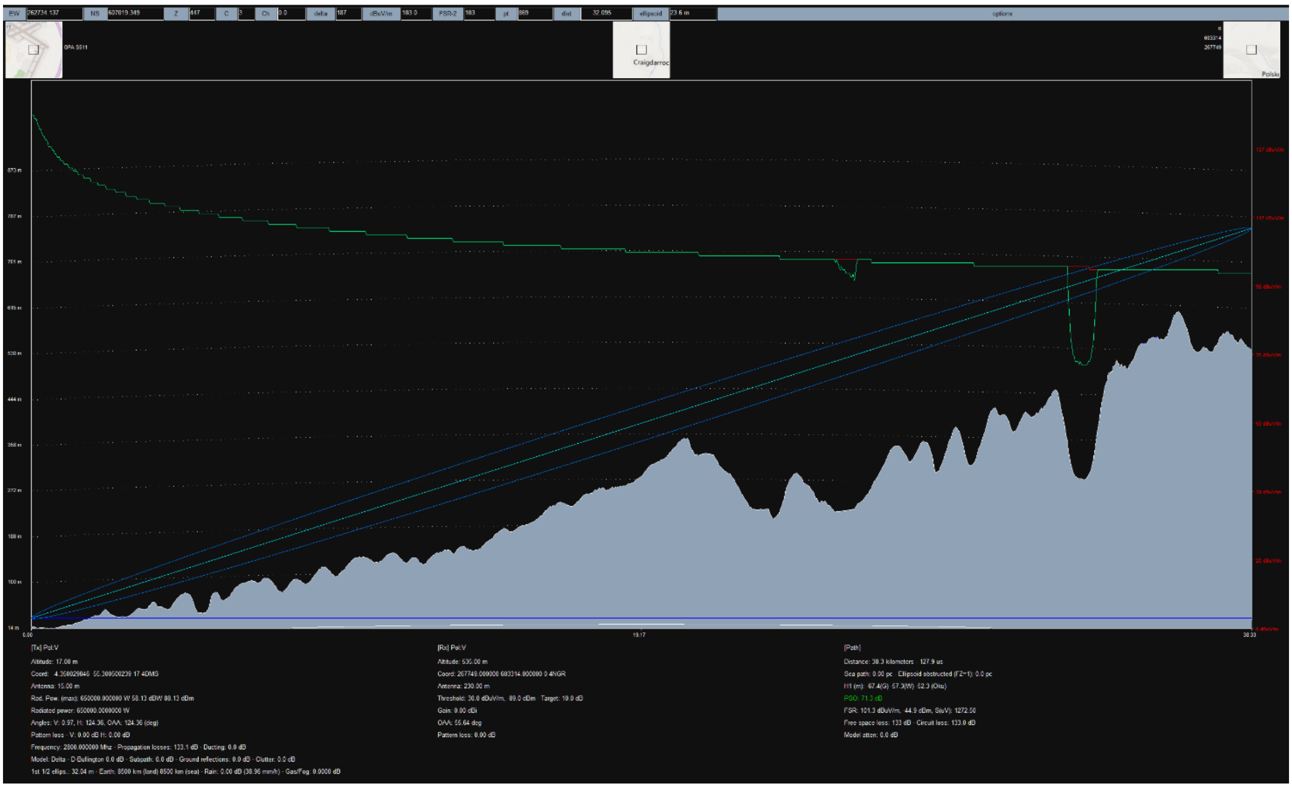
A.4. Turbine 4



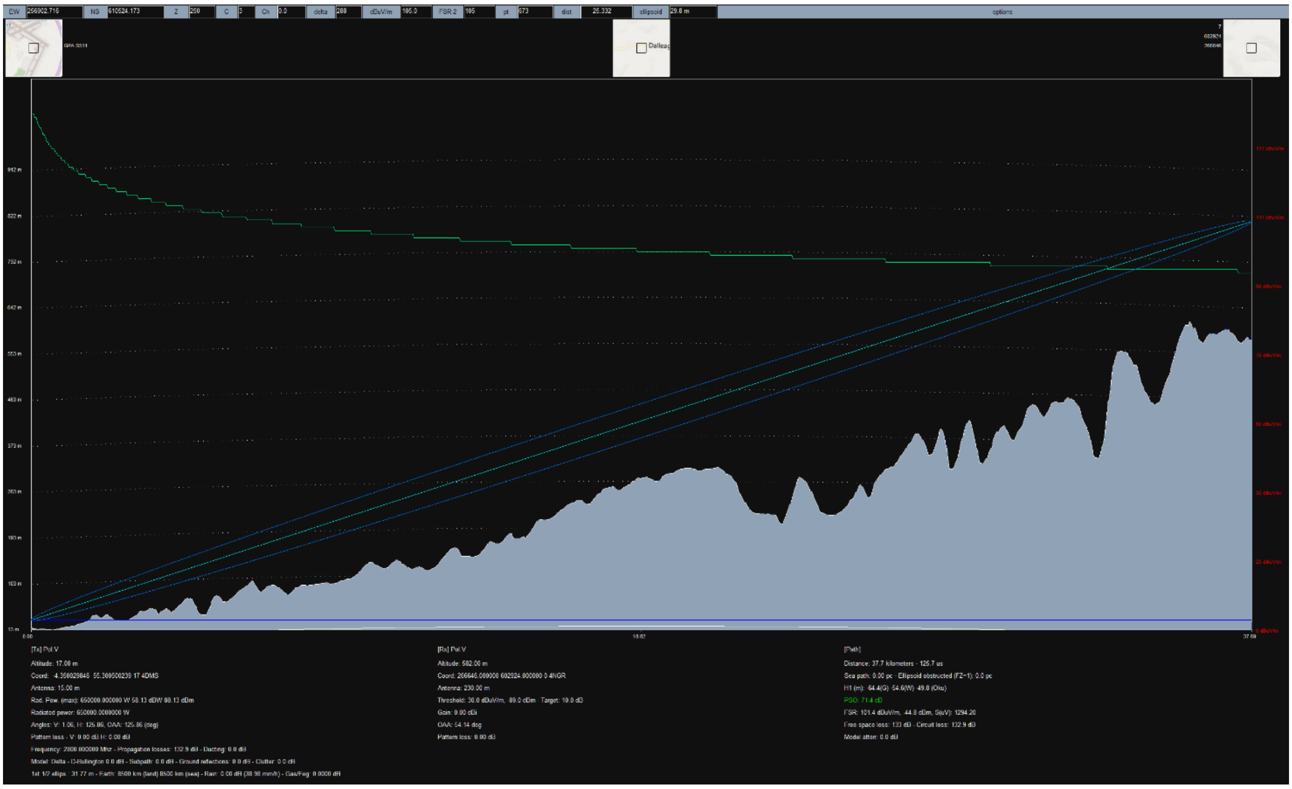
A.5. Turbine 5



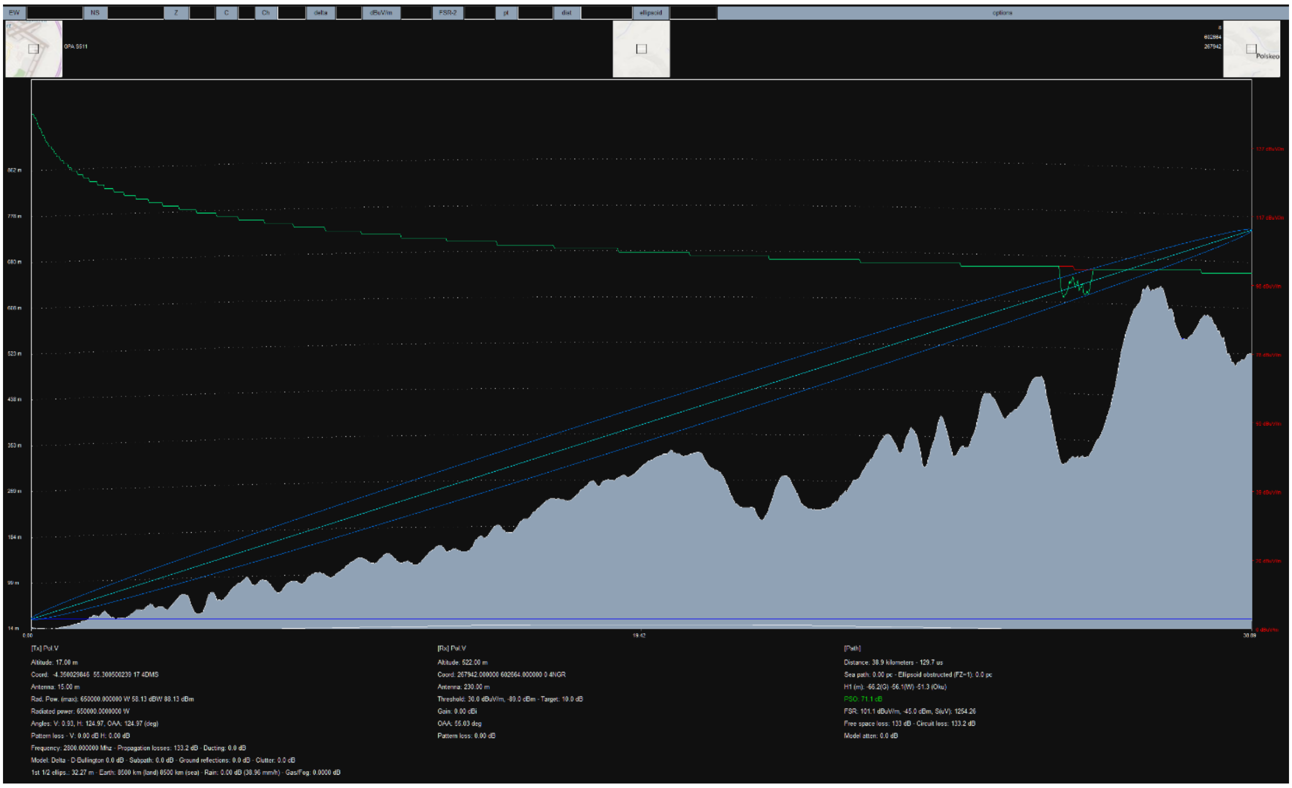
A.6. Turbine 6



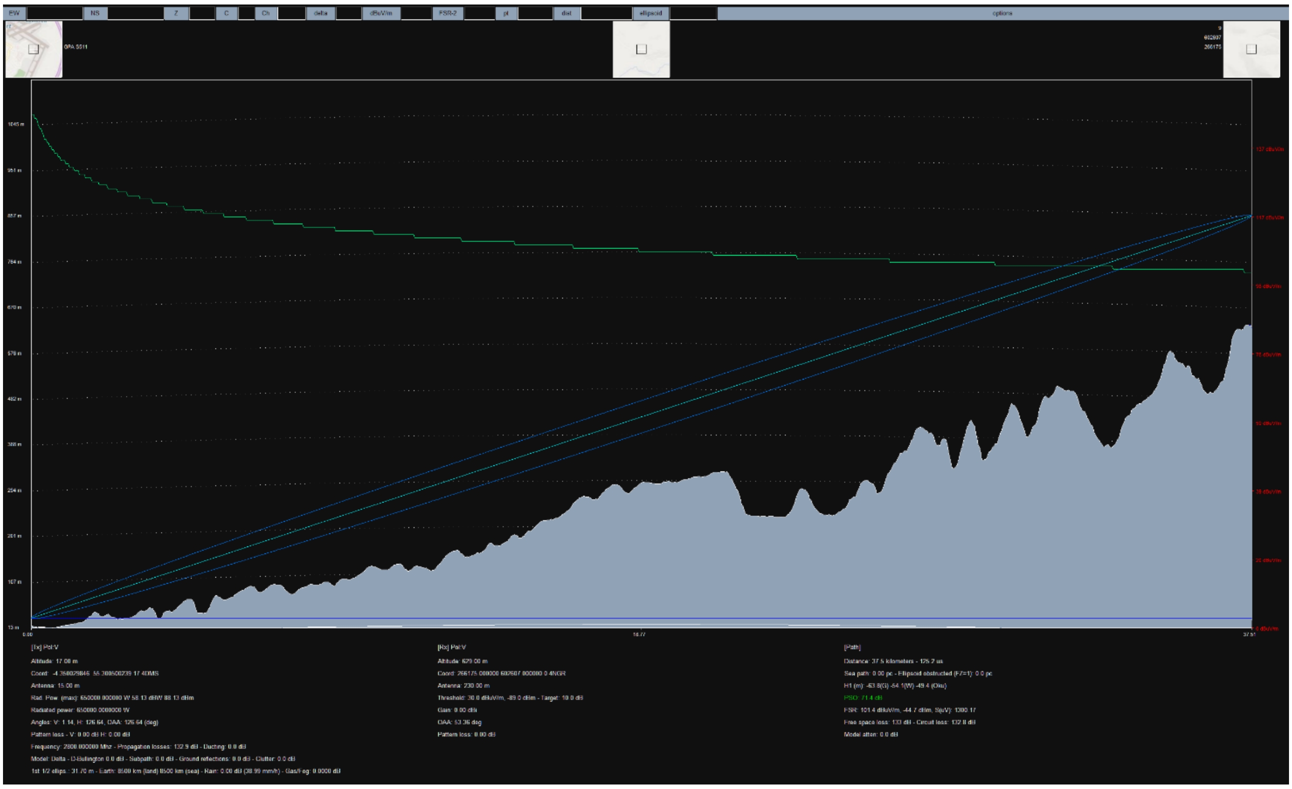
A.7. Turbine 7



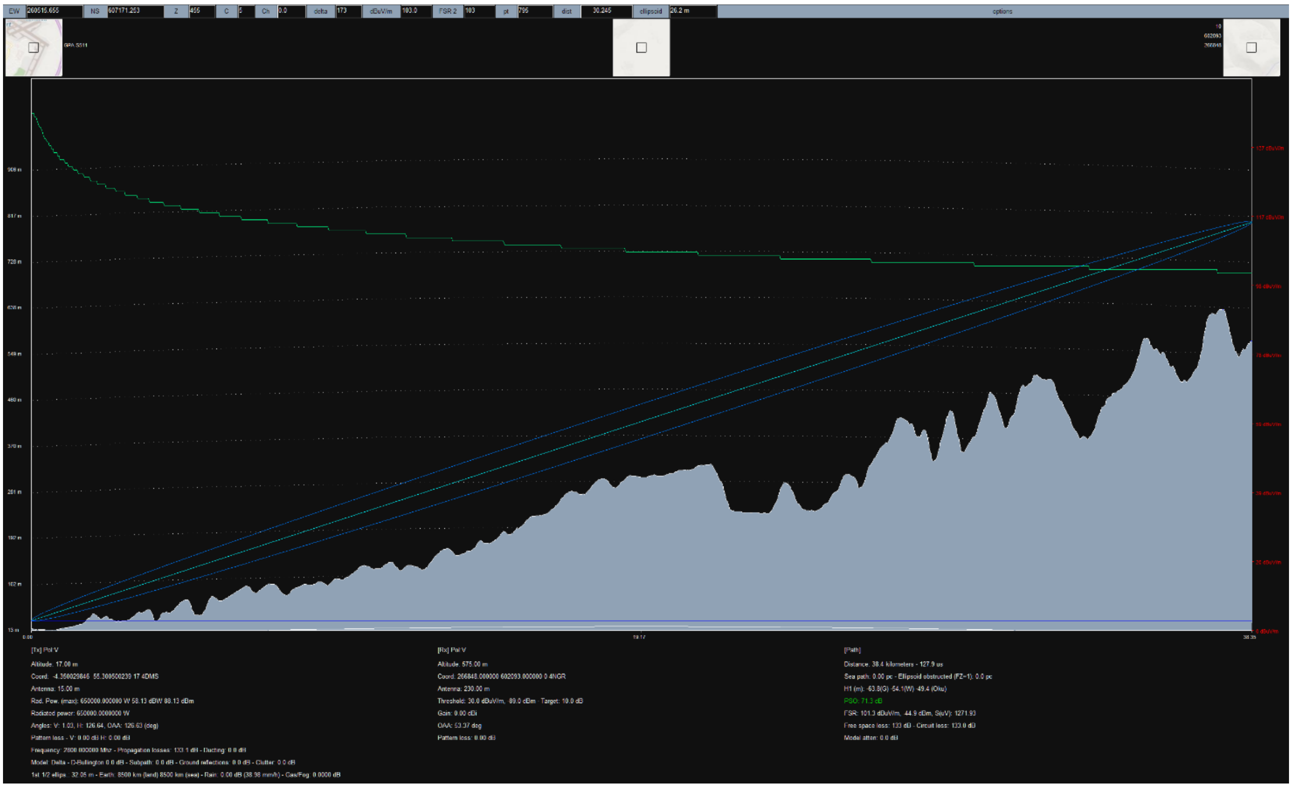
A.8. Turbine 8



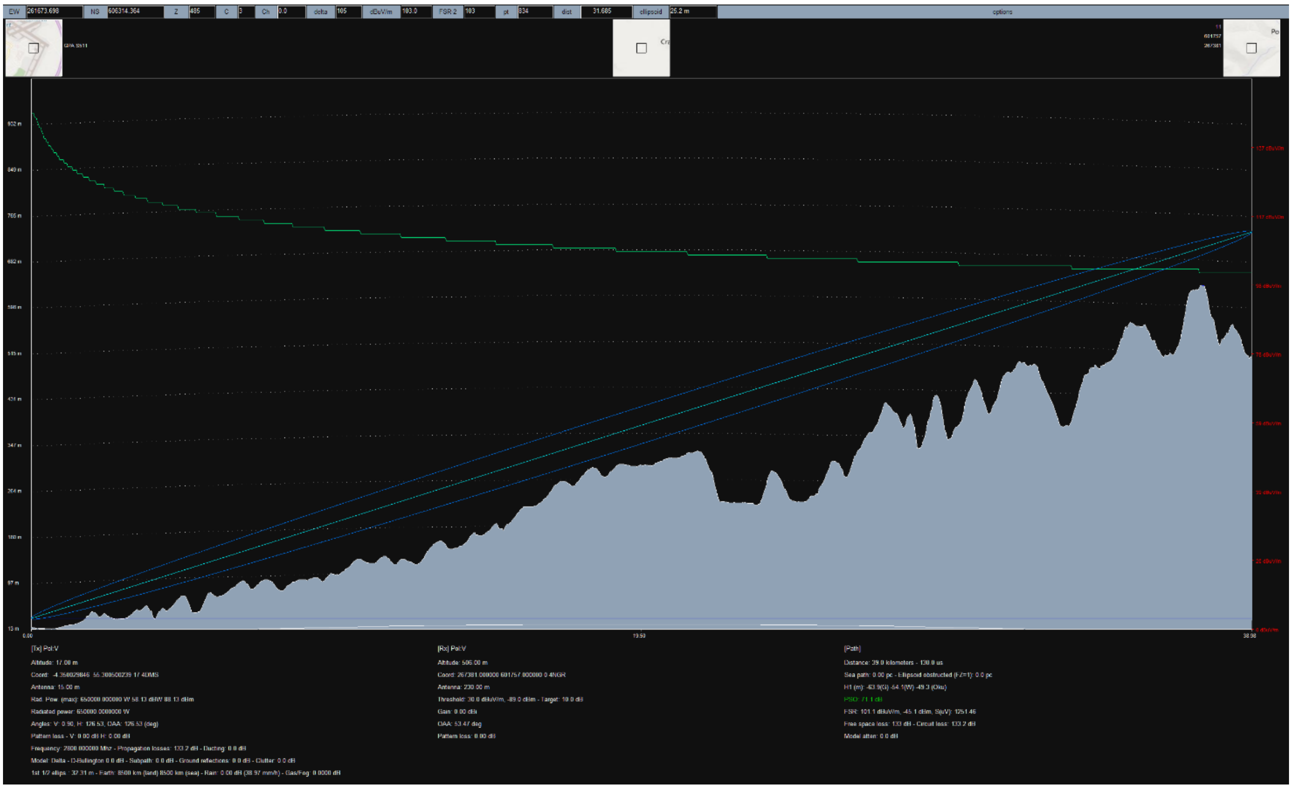
A.9. Turbine 9



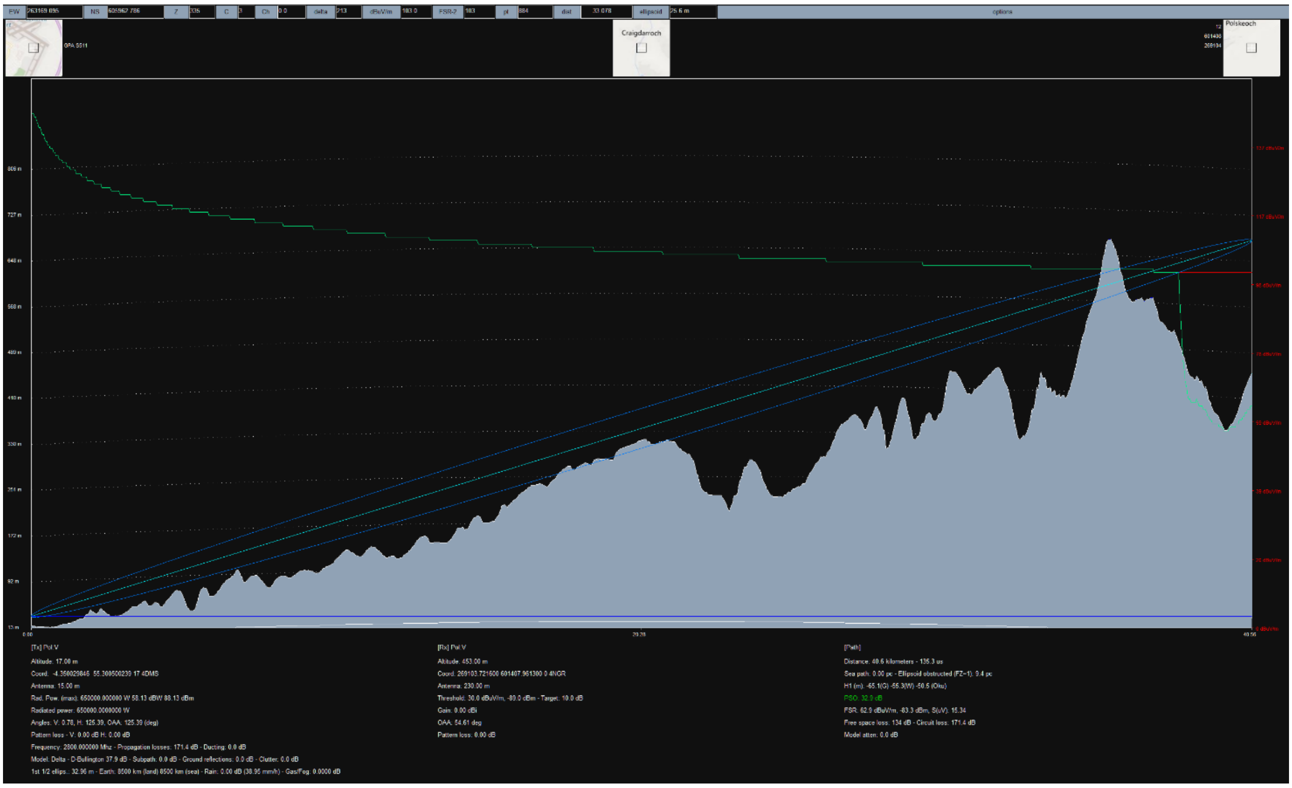
A.10. Turbine 10



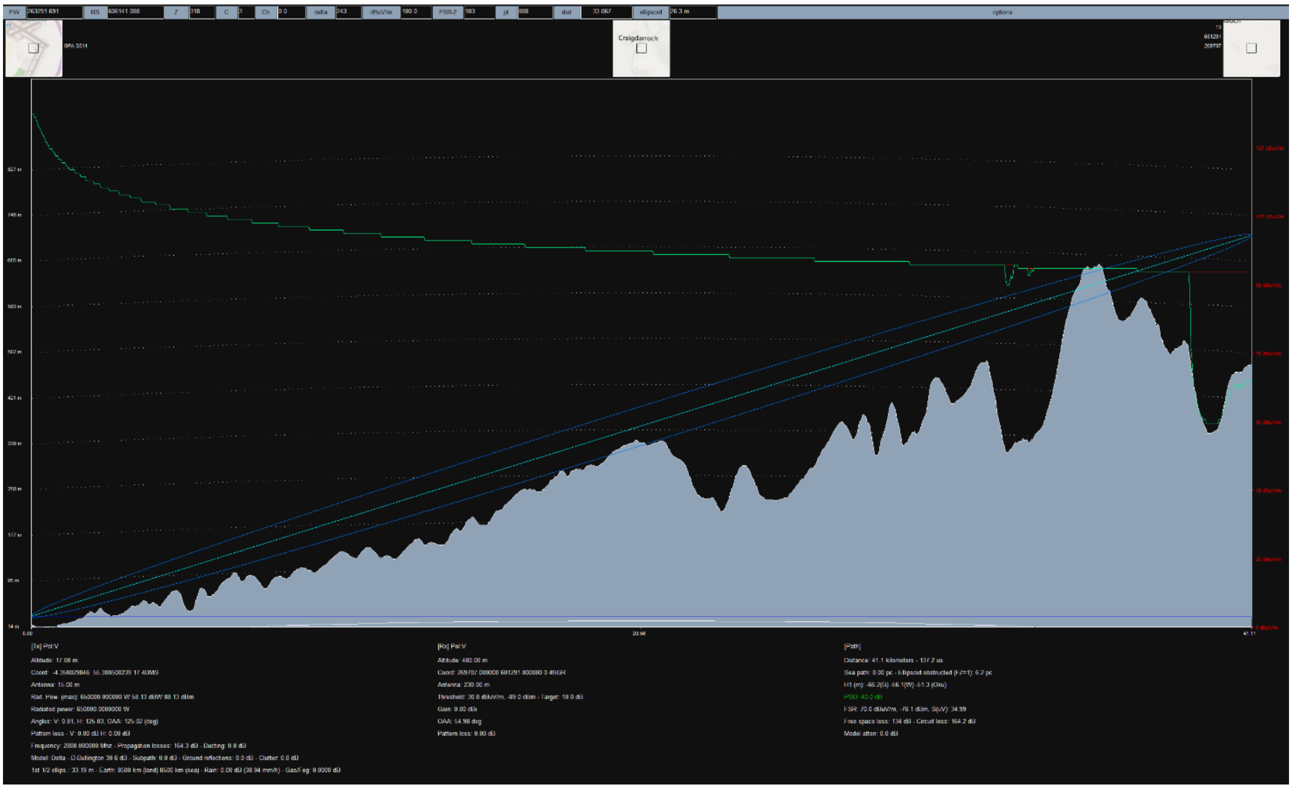
A.11. Turbine 11



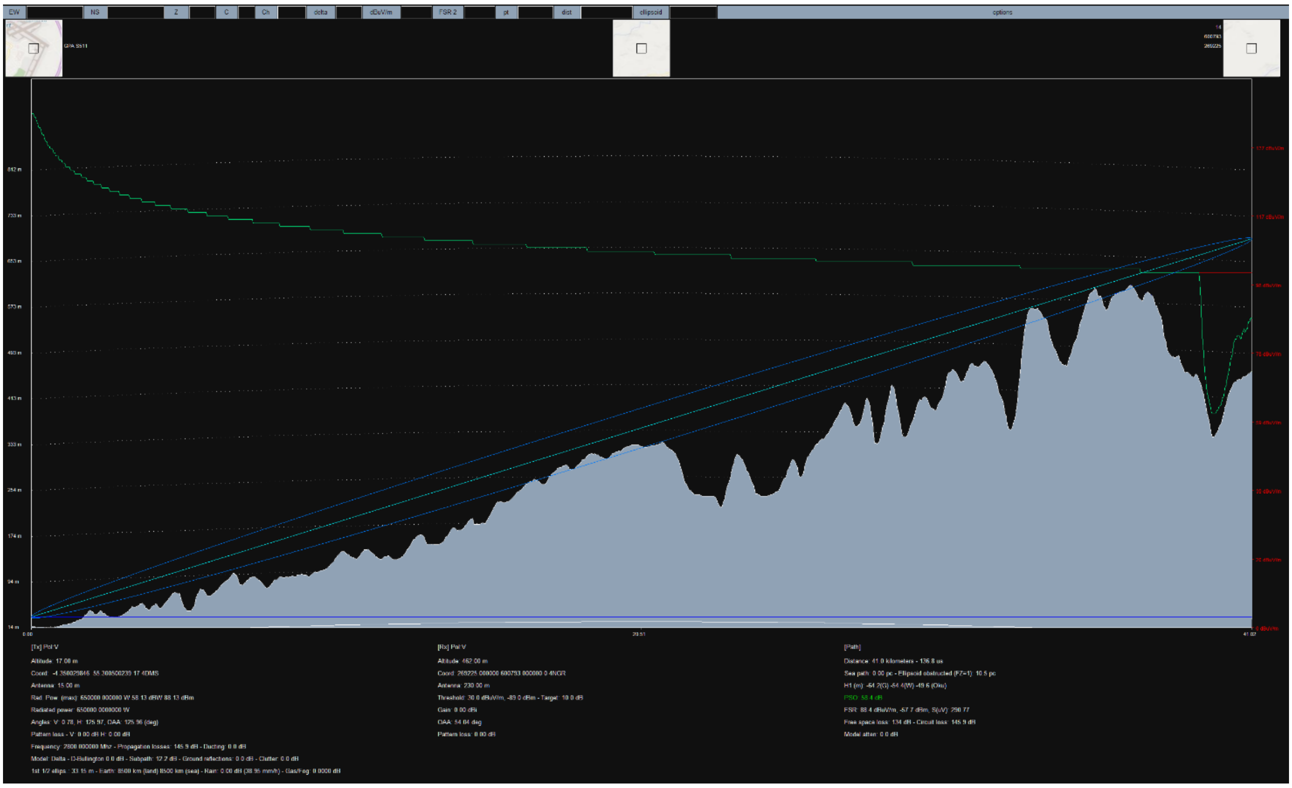
A.12. Turbine 12



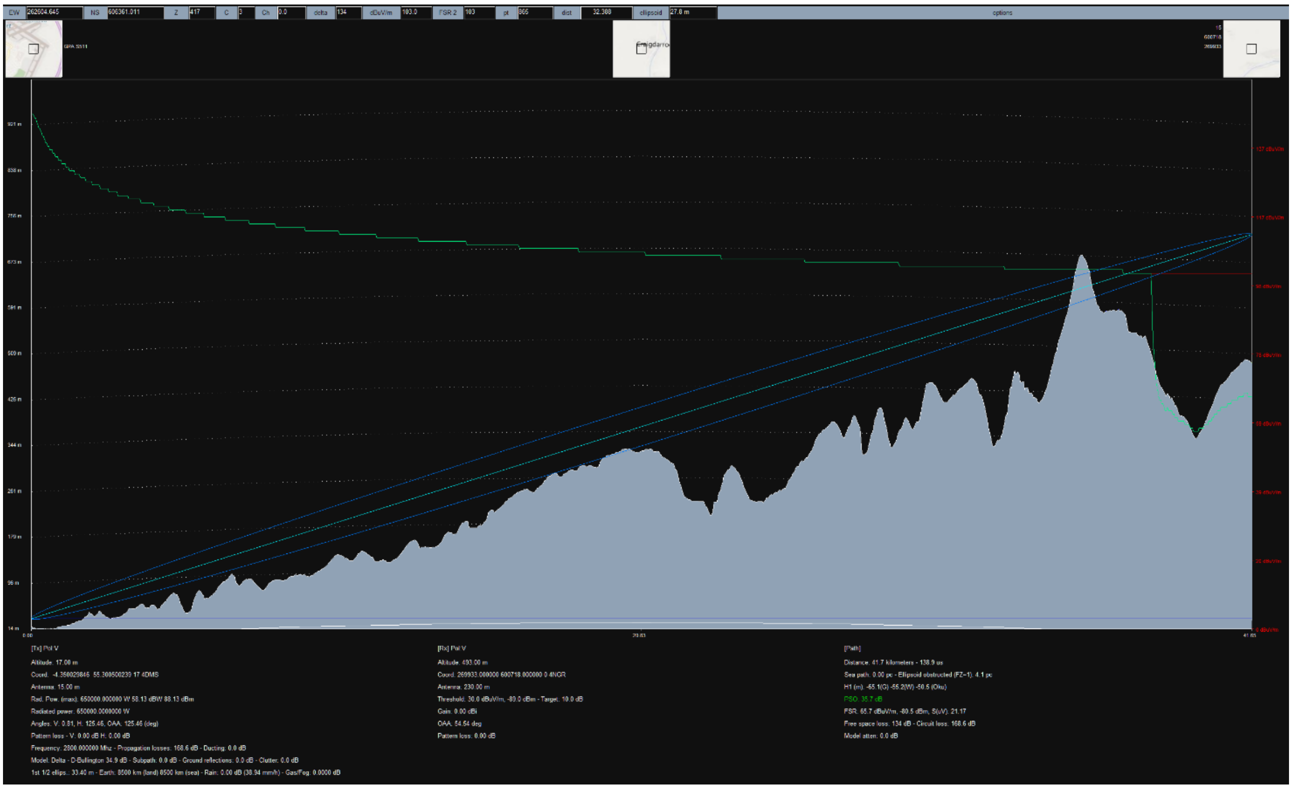
A.13. Turbine 13



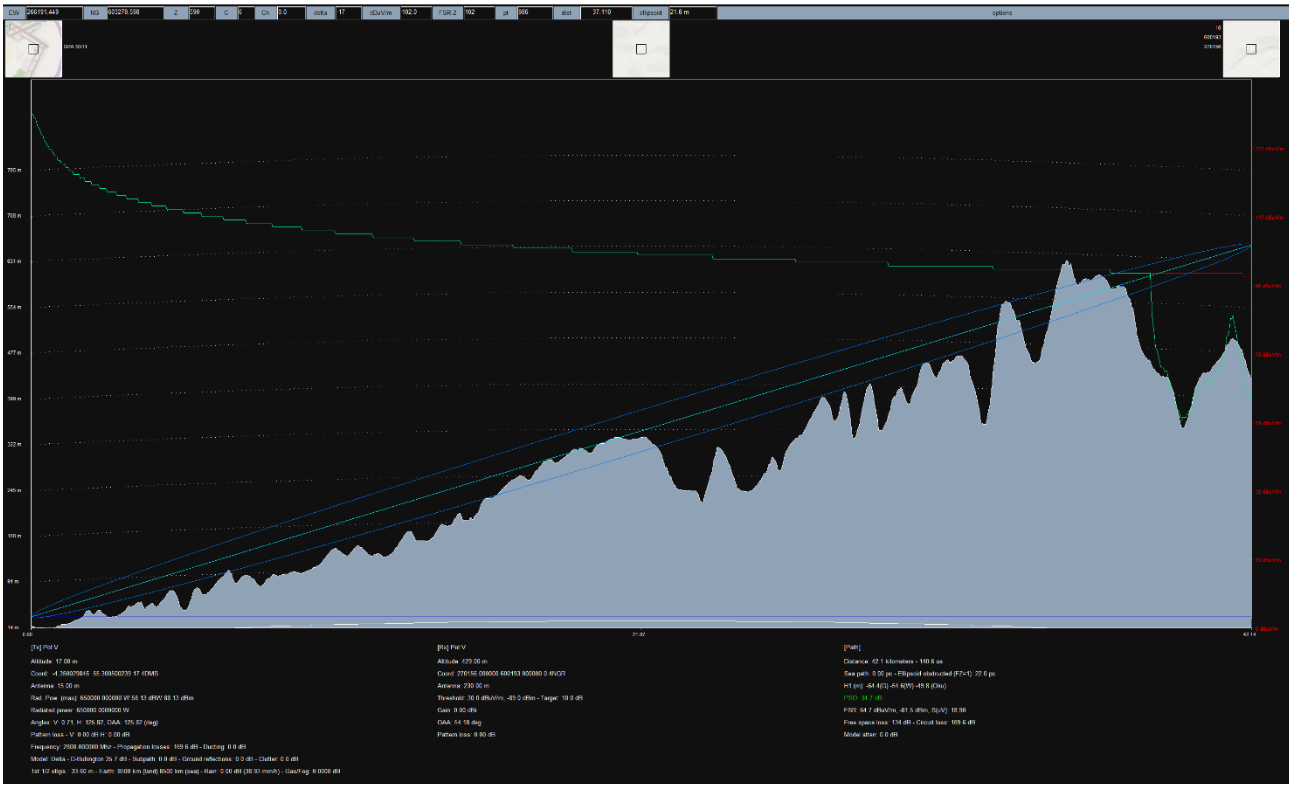
A.14. Turbine 14



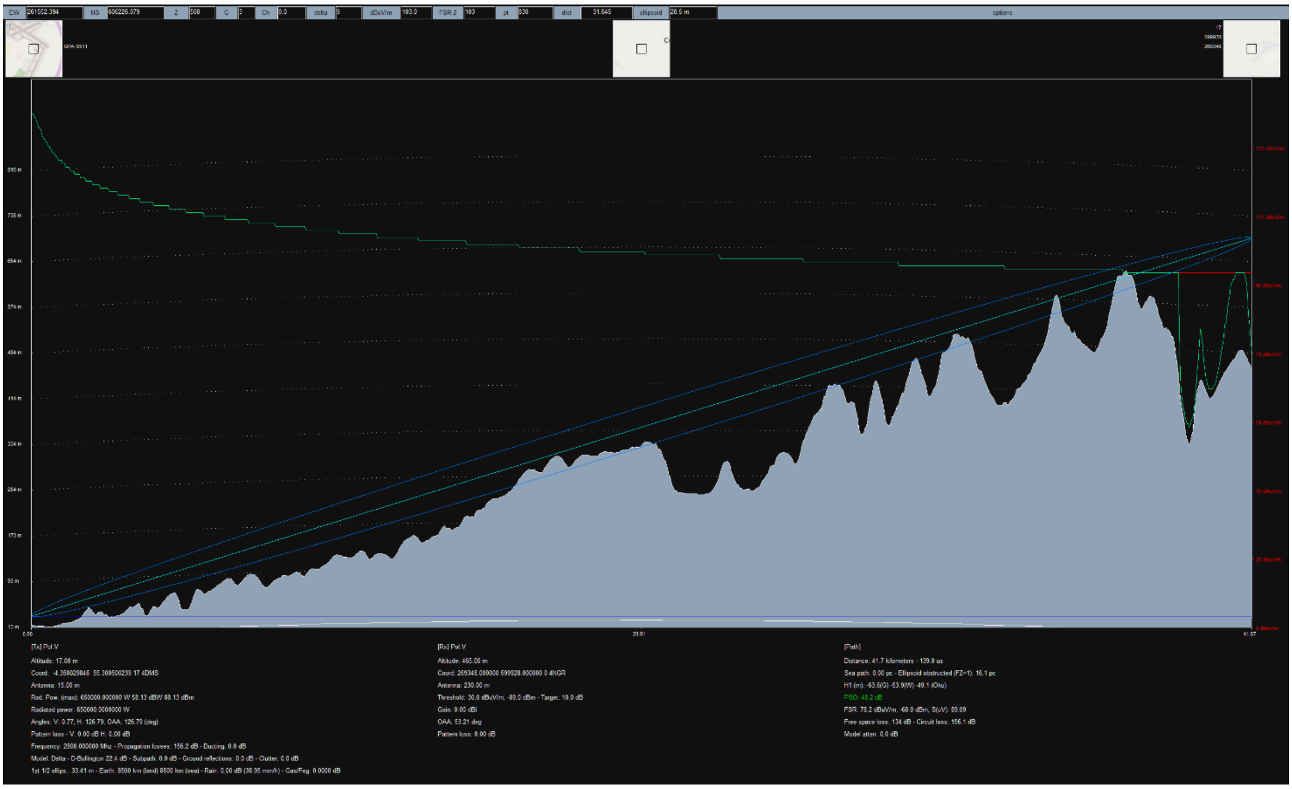
A.15. Turbine 15



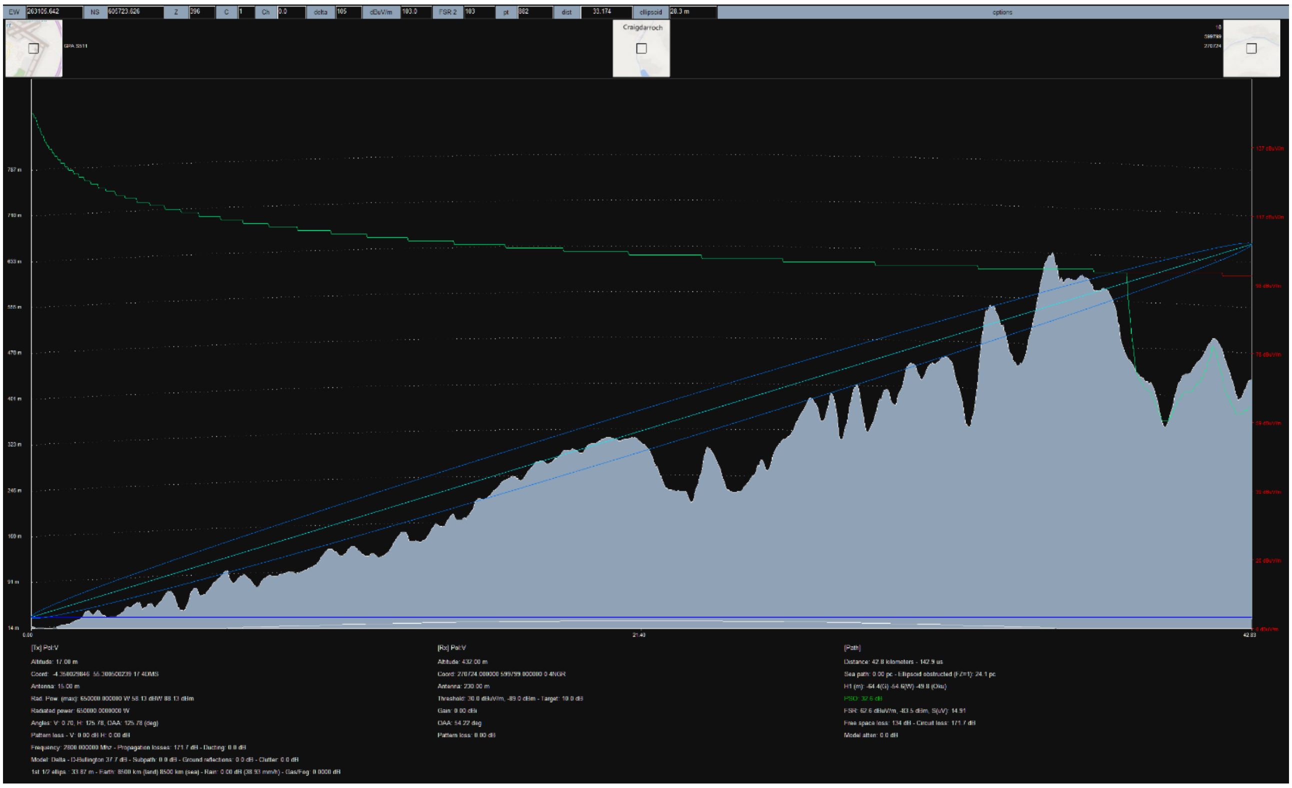
A.16. Turbine 16



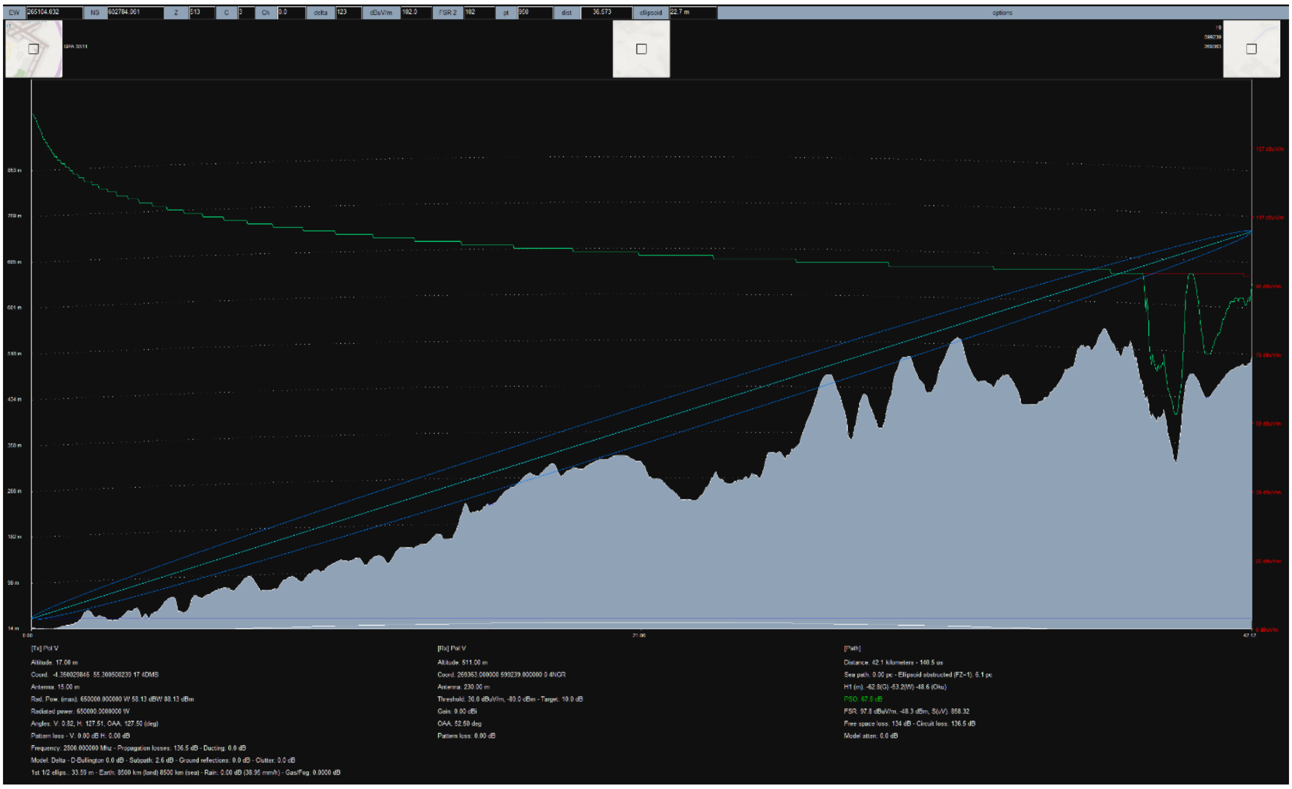
A.17. Turbine 17



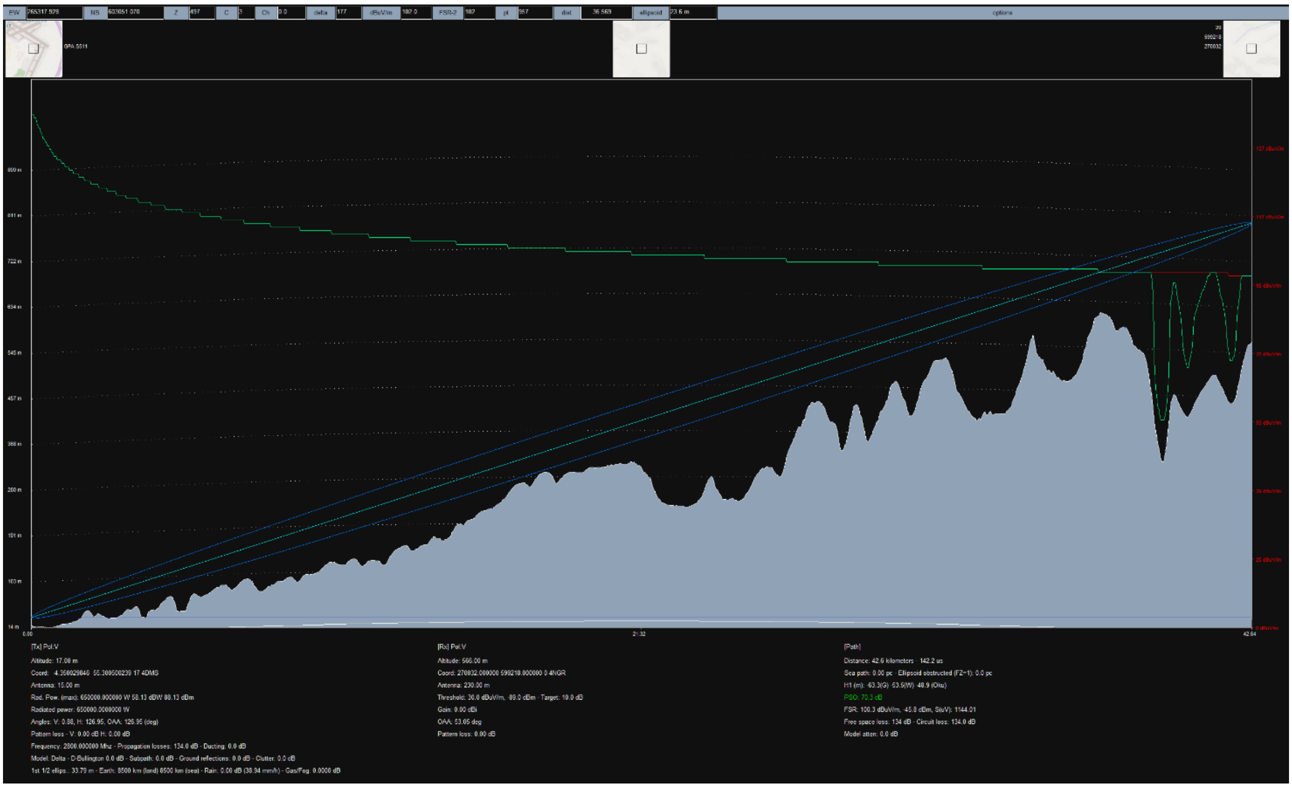
A.18. Turbine 18



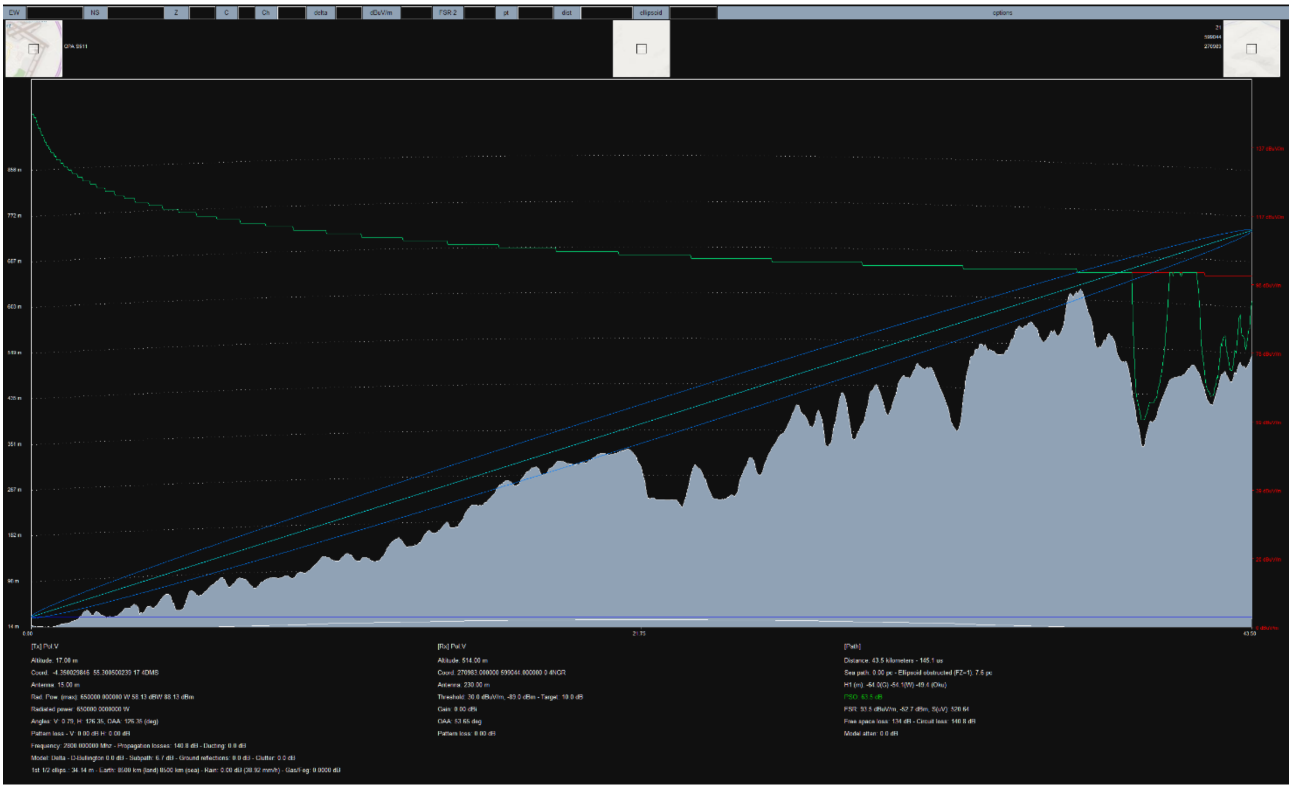
A.19. Turbine 19



A.20. Turbine 20

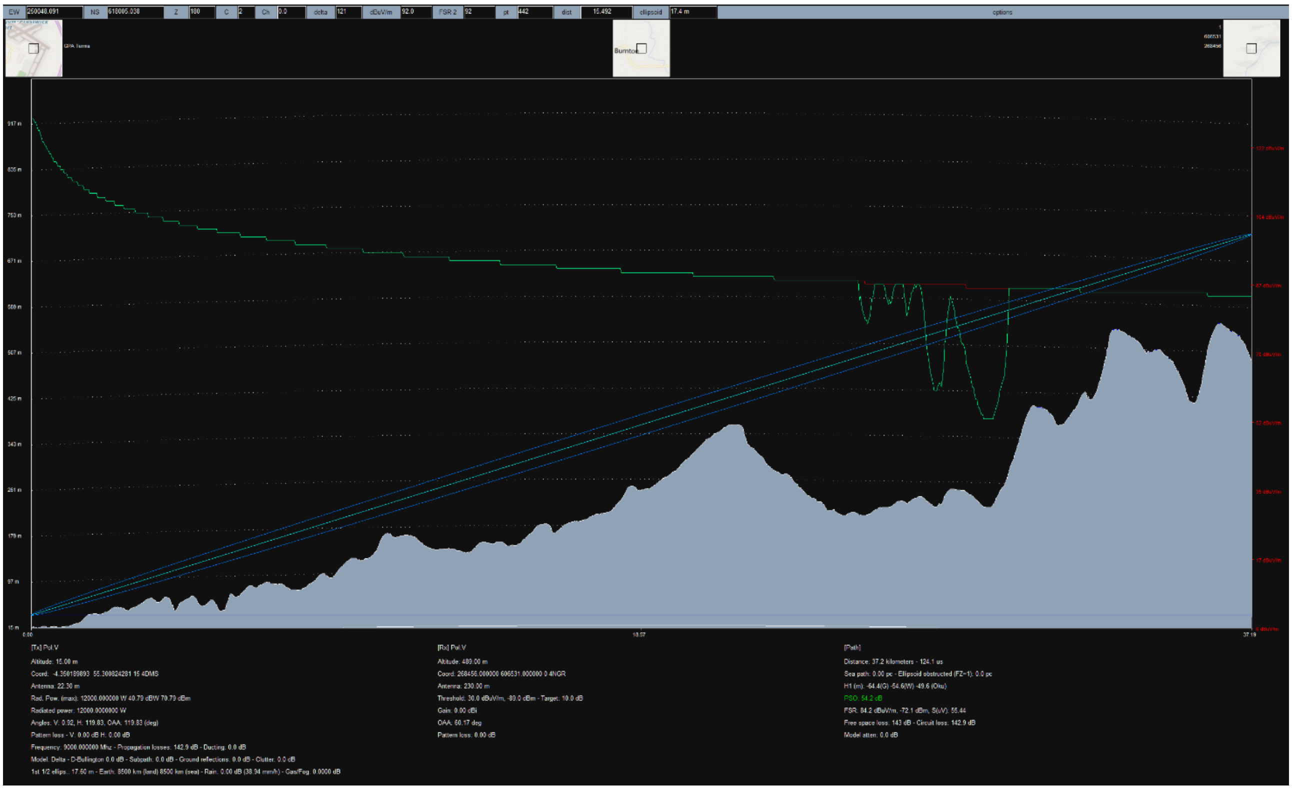


A.21. Turbine 21

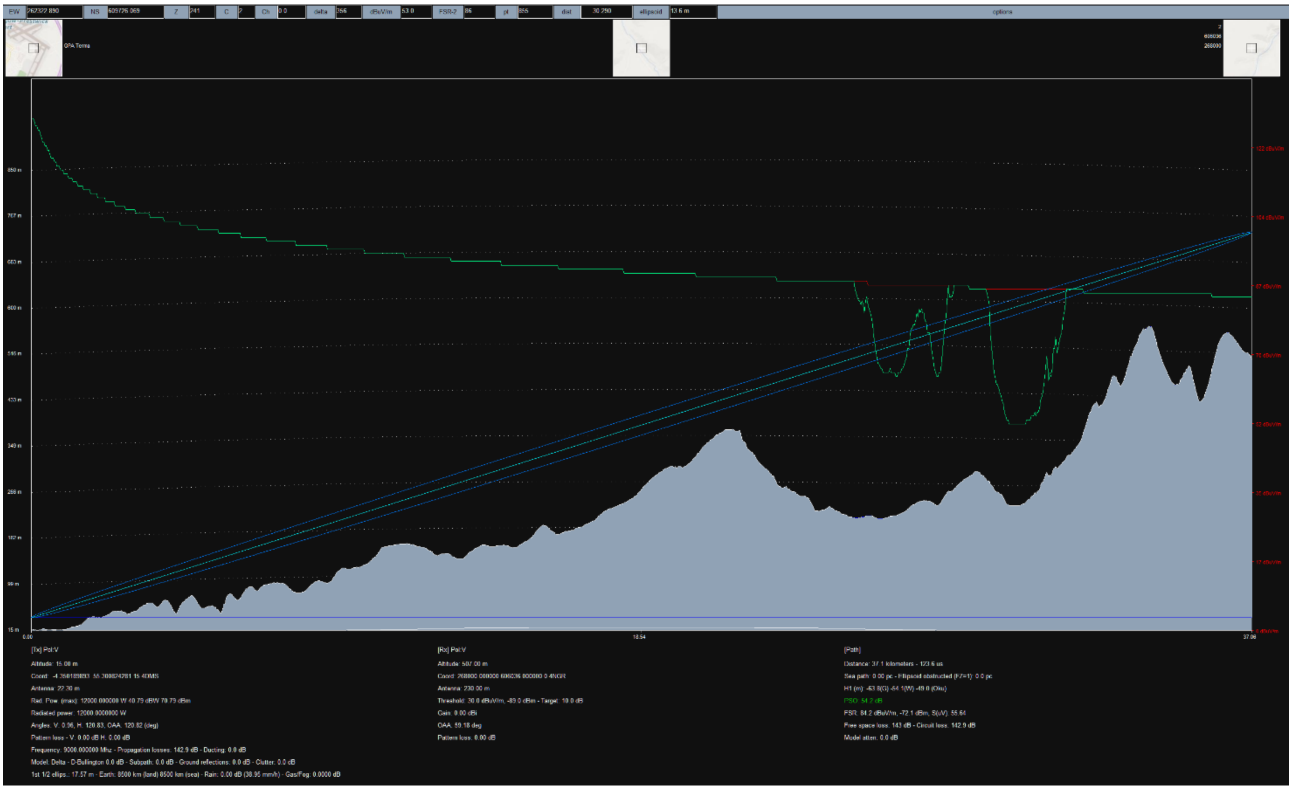


B. Annex B – GPA Terma PSR Path Profiles

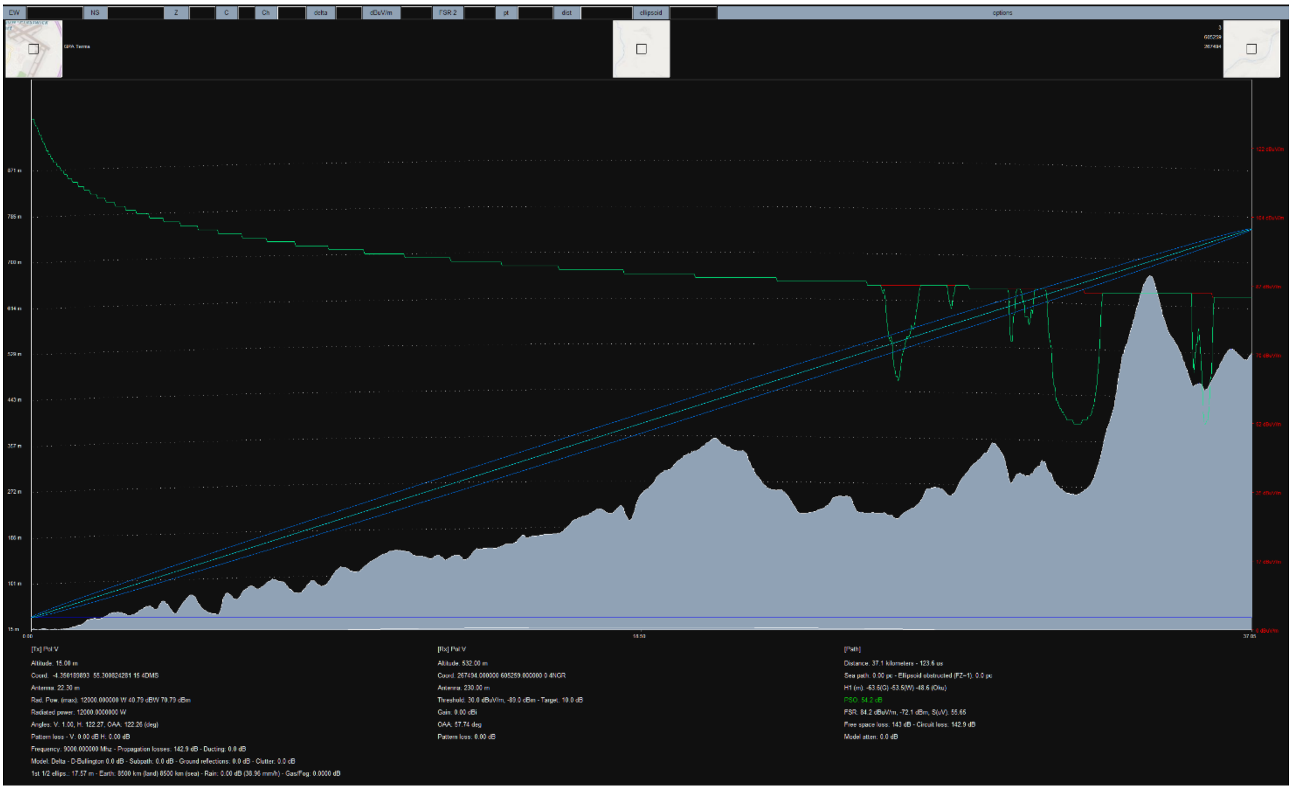
B.1. Turbine 1



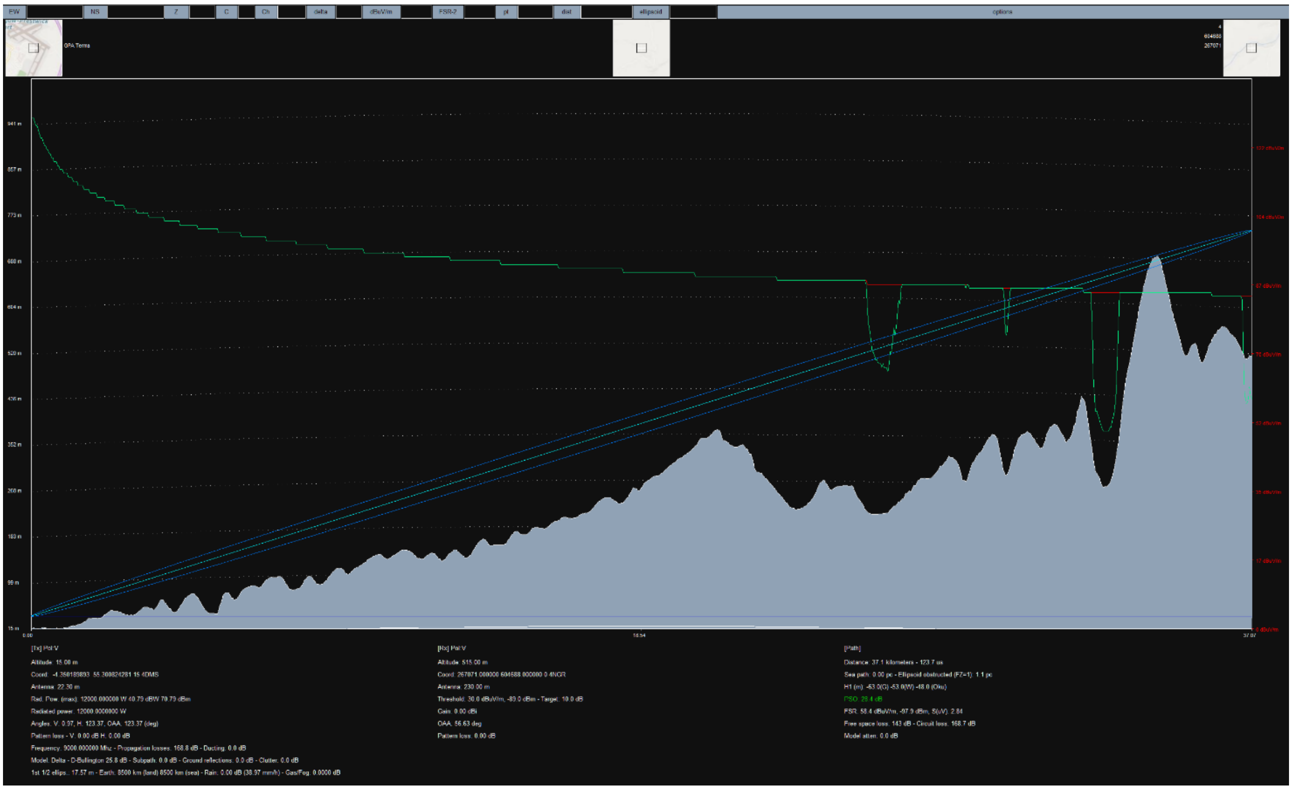
B.2. Turbine 2



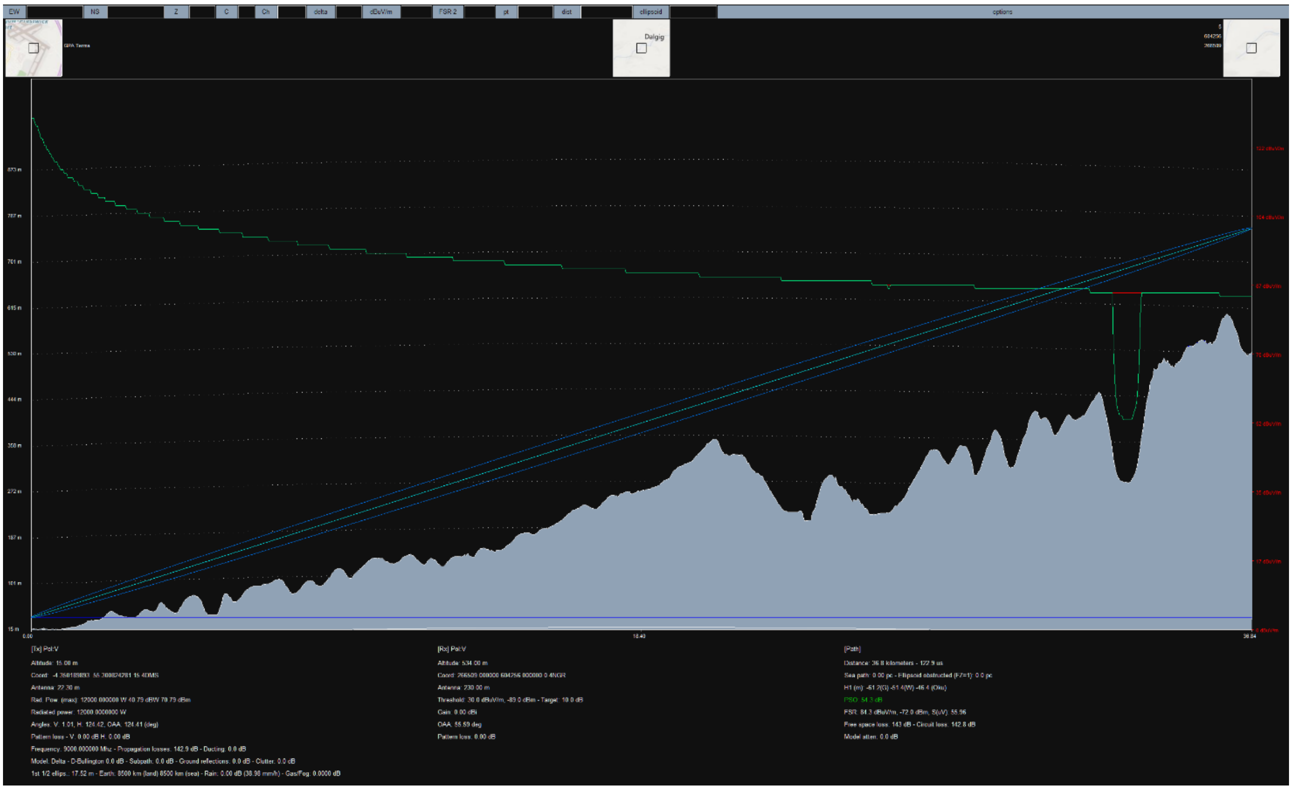
B.3. Turbine 3



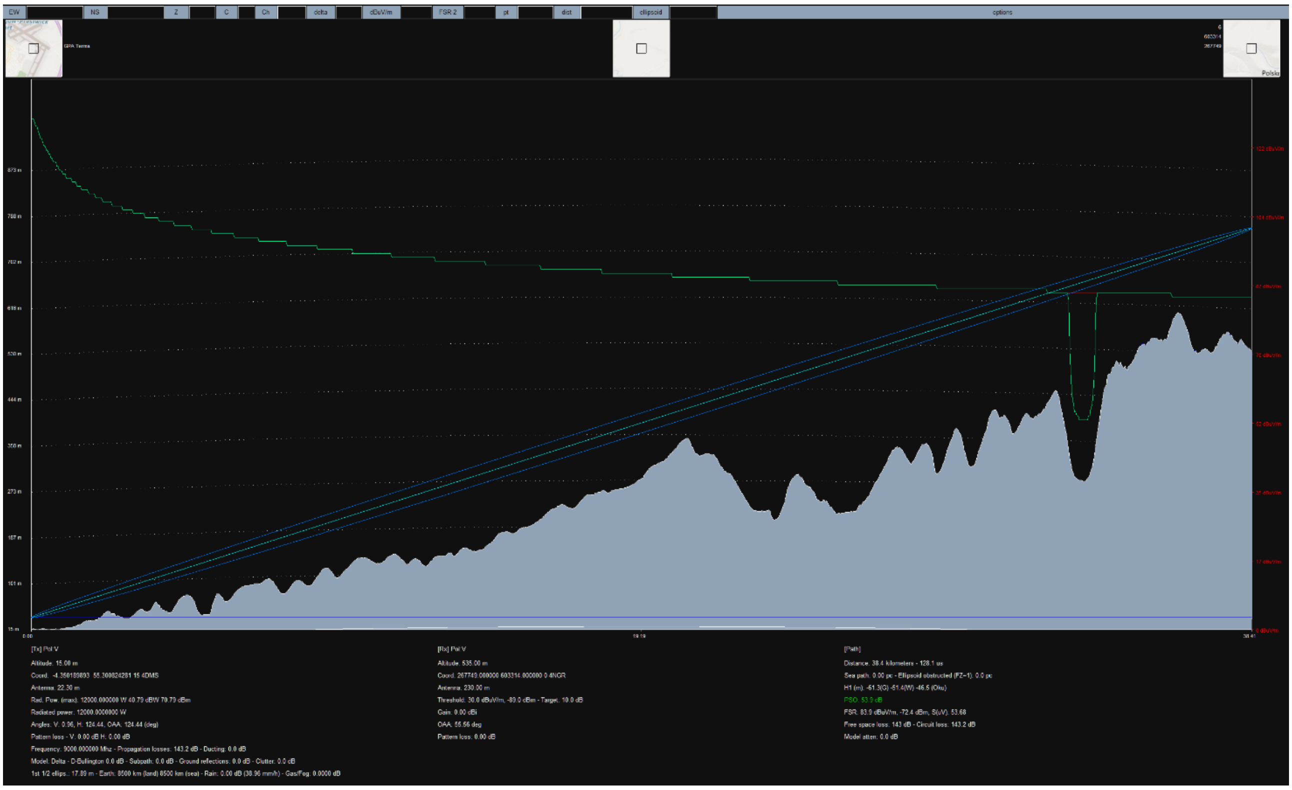
B.4. Turbine 4



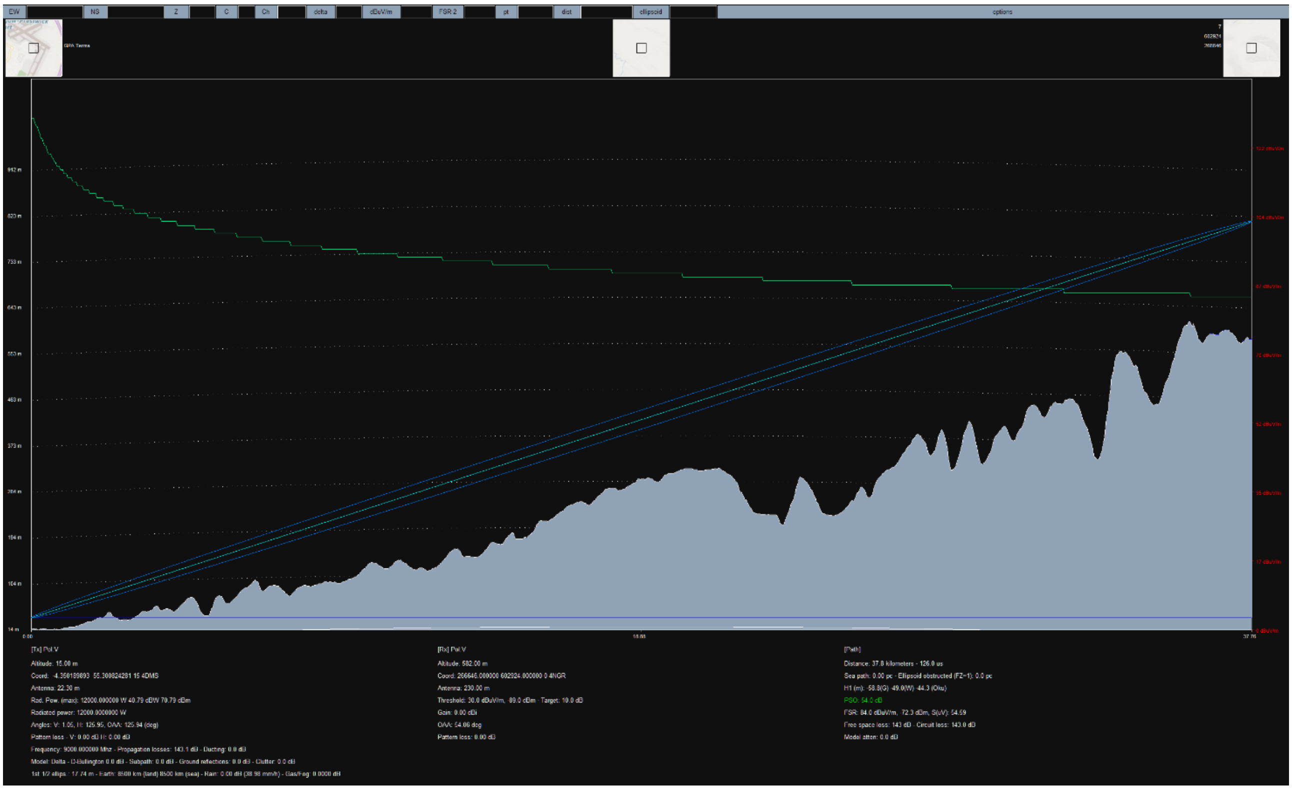
B.5. Turbine 5



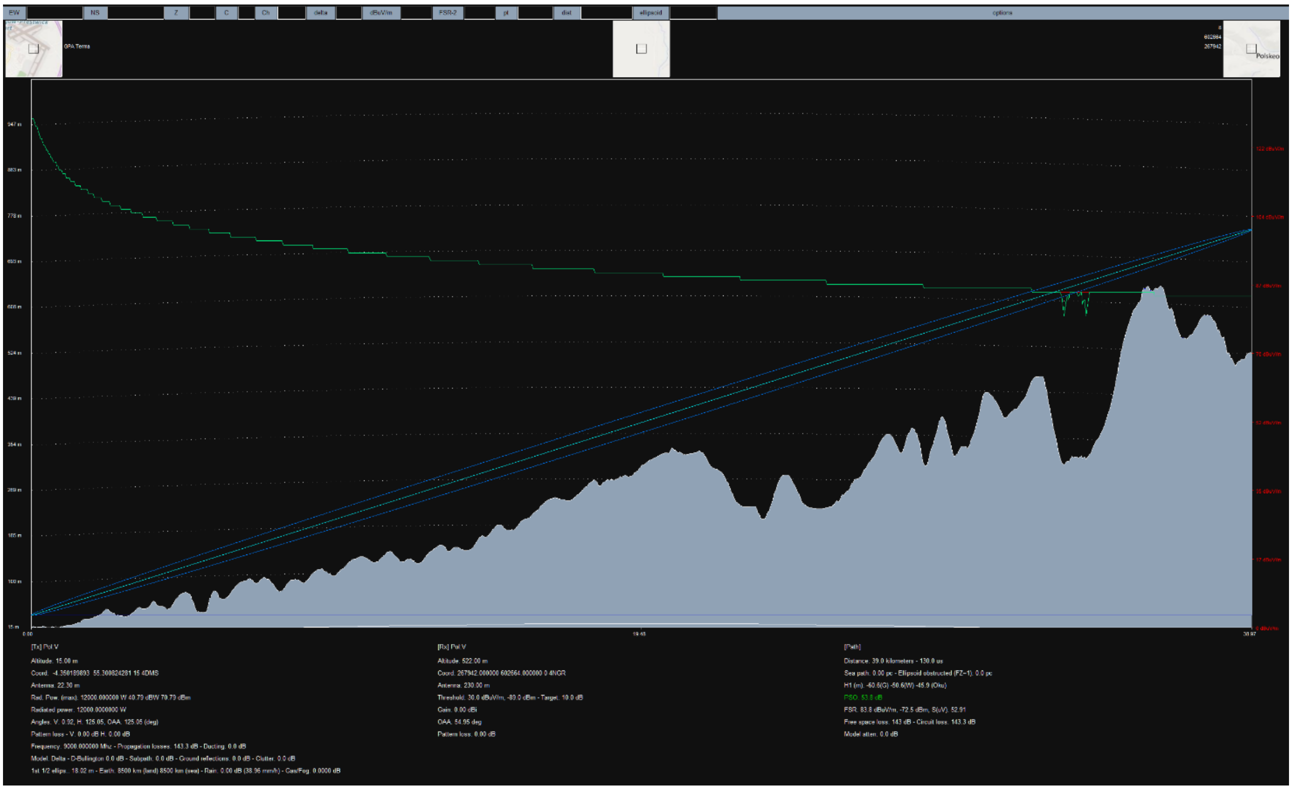
B.6. Turbine 6



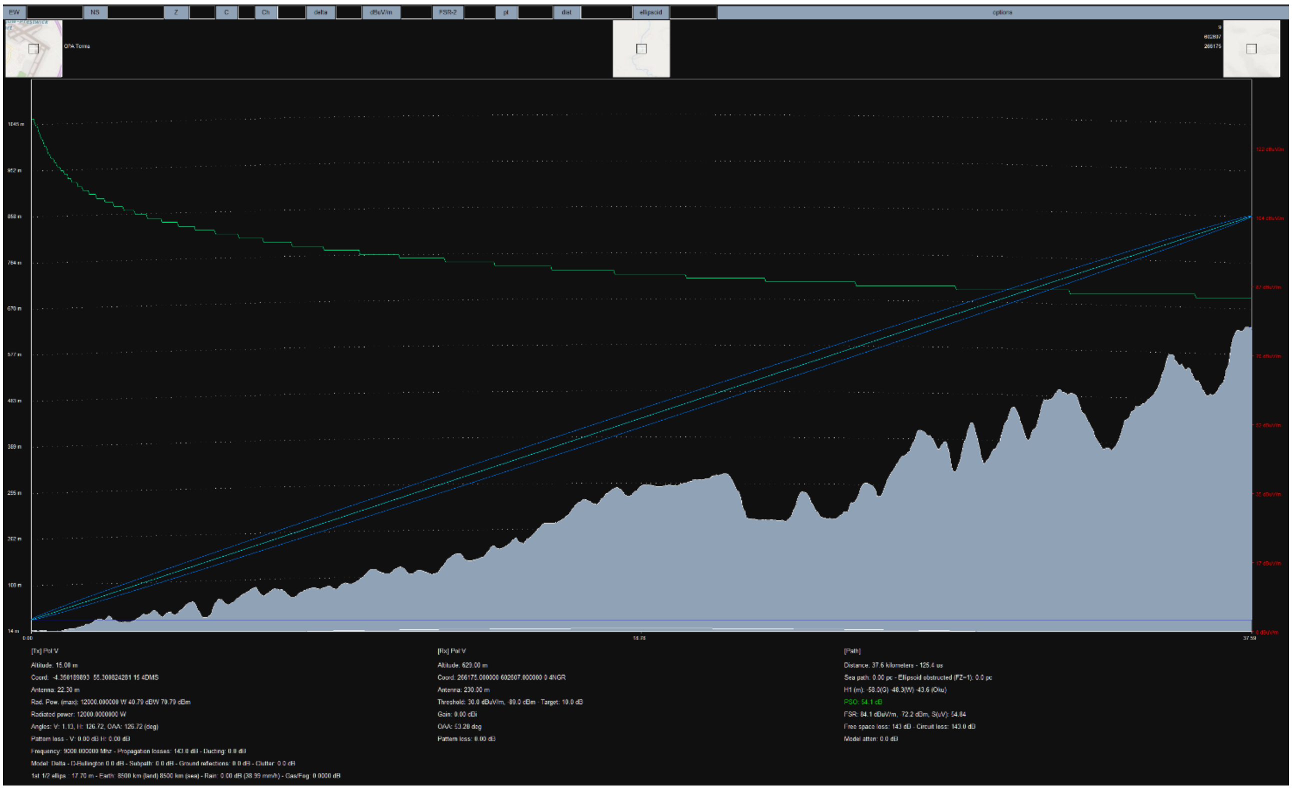
B.7. Turbine 7



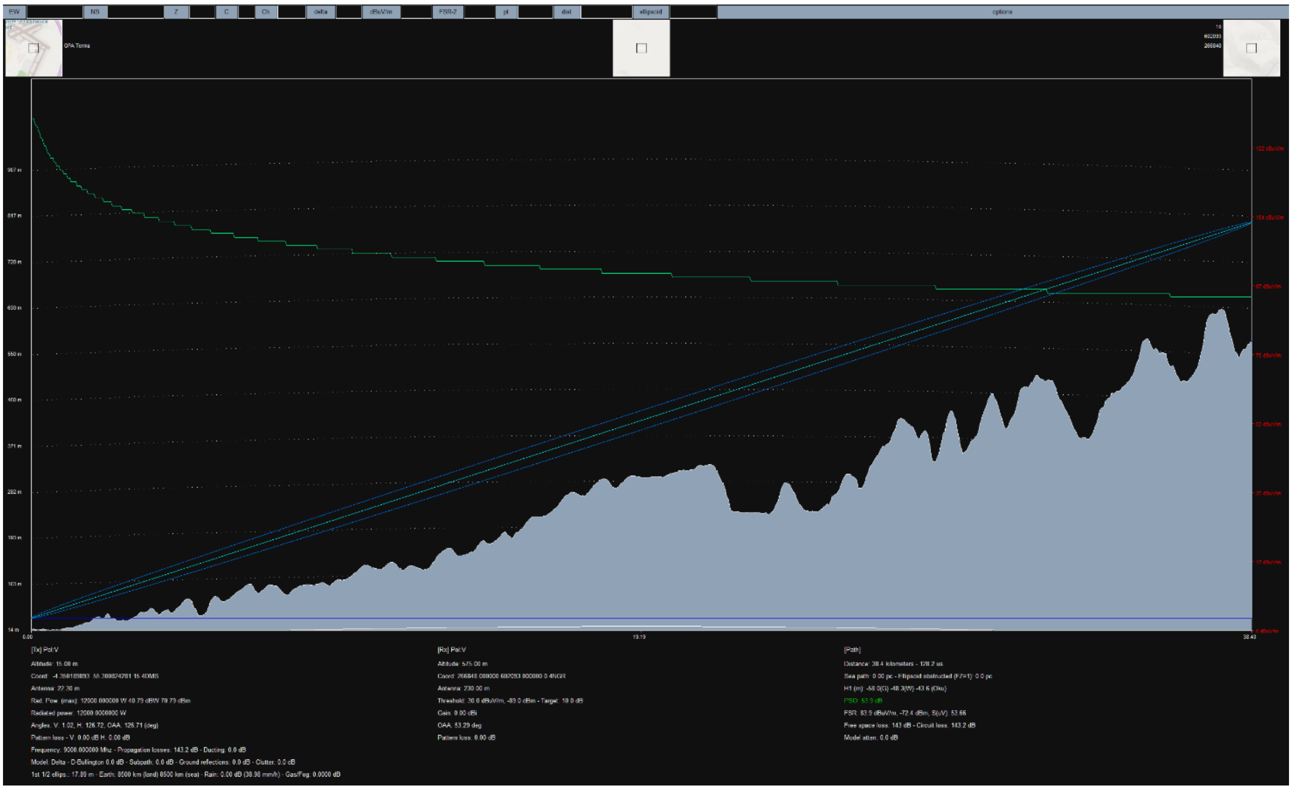
B.8. Turbine 8



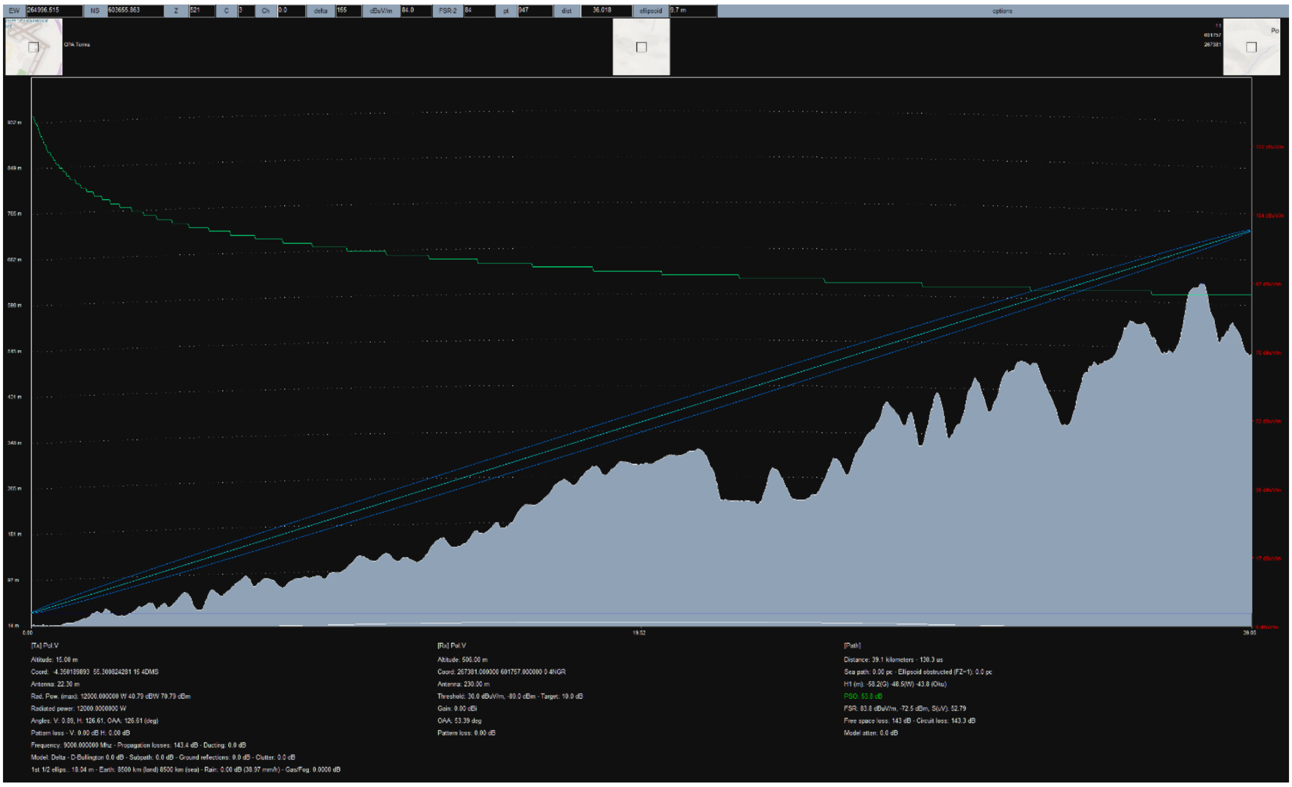
B.9. Turbine 9



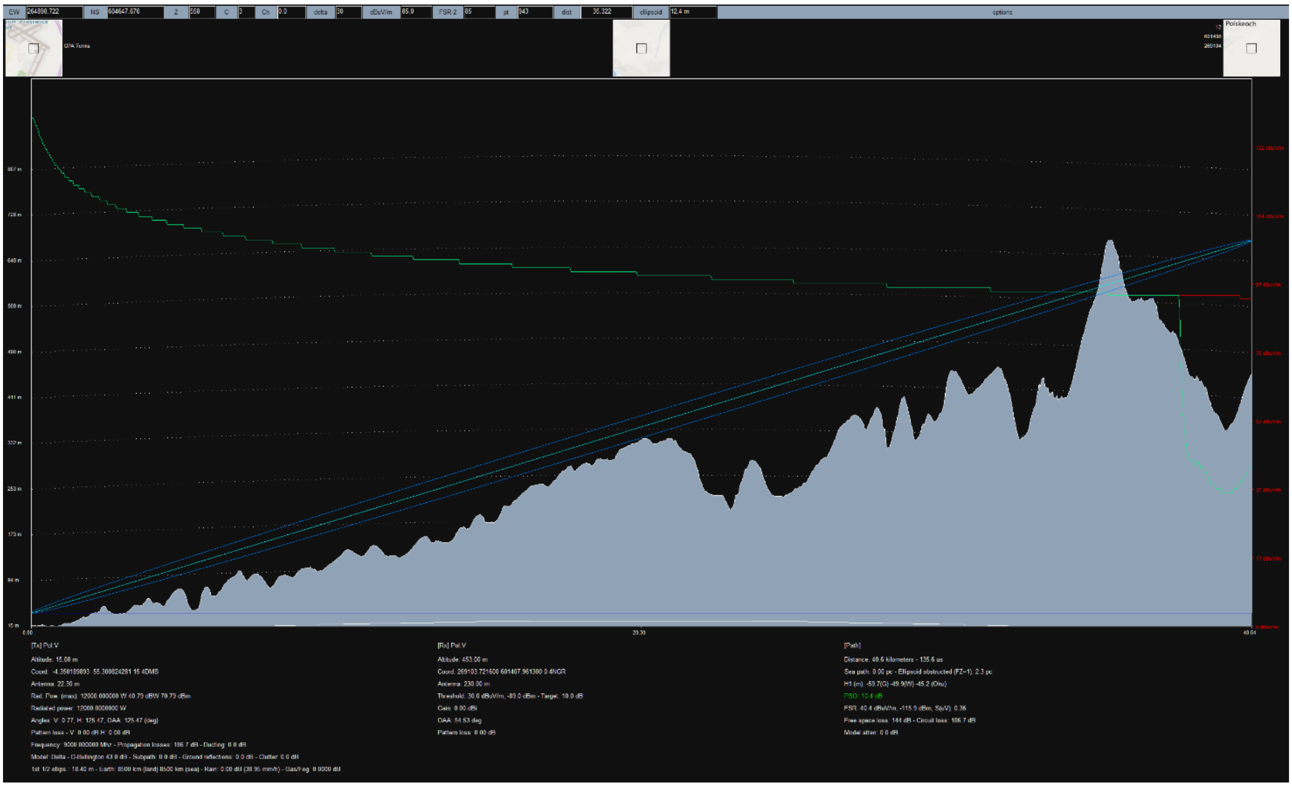
B.10. Turbine 10



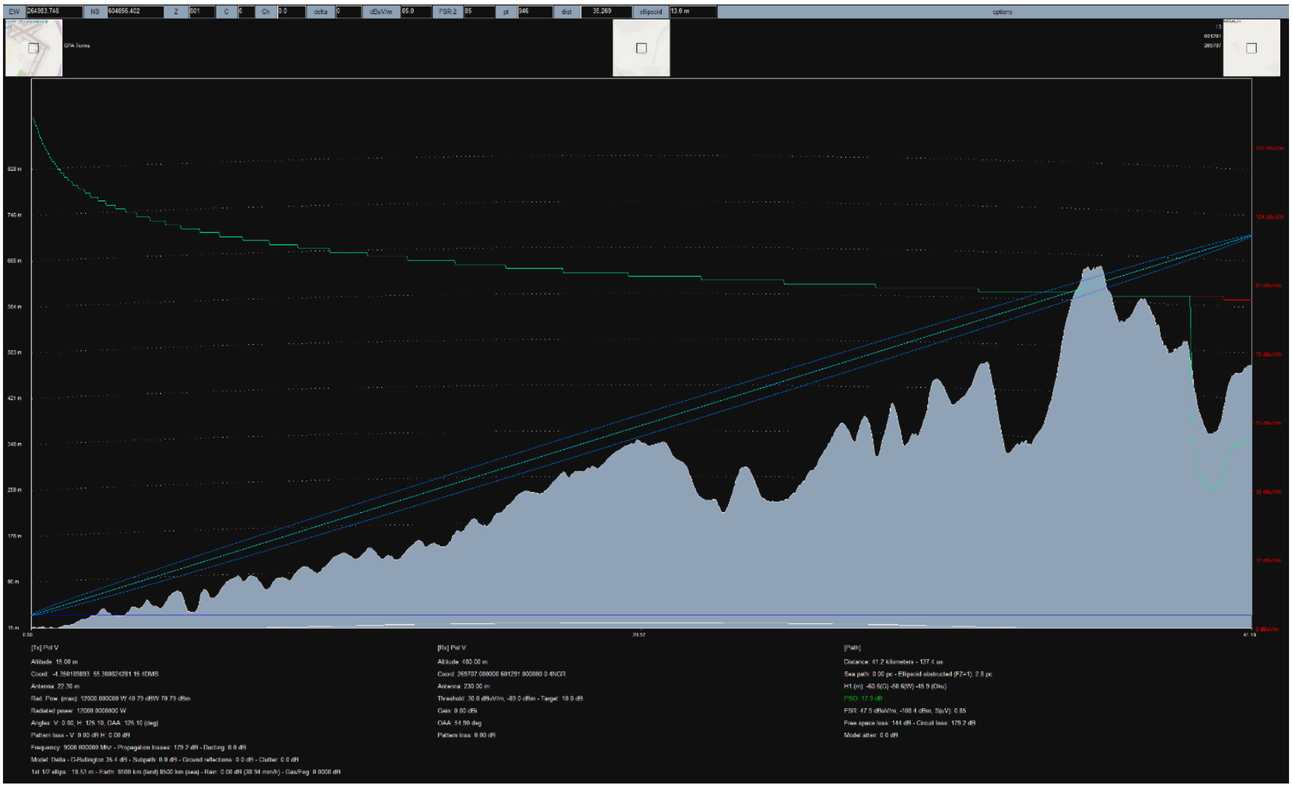
B.11. Turbine 11



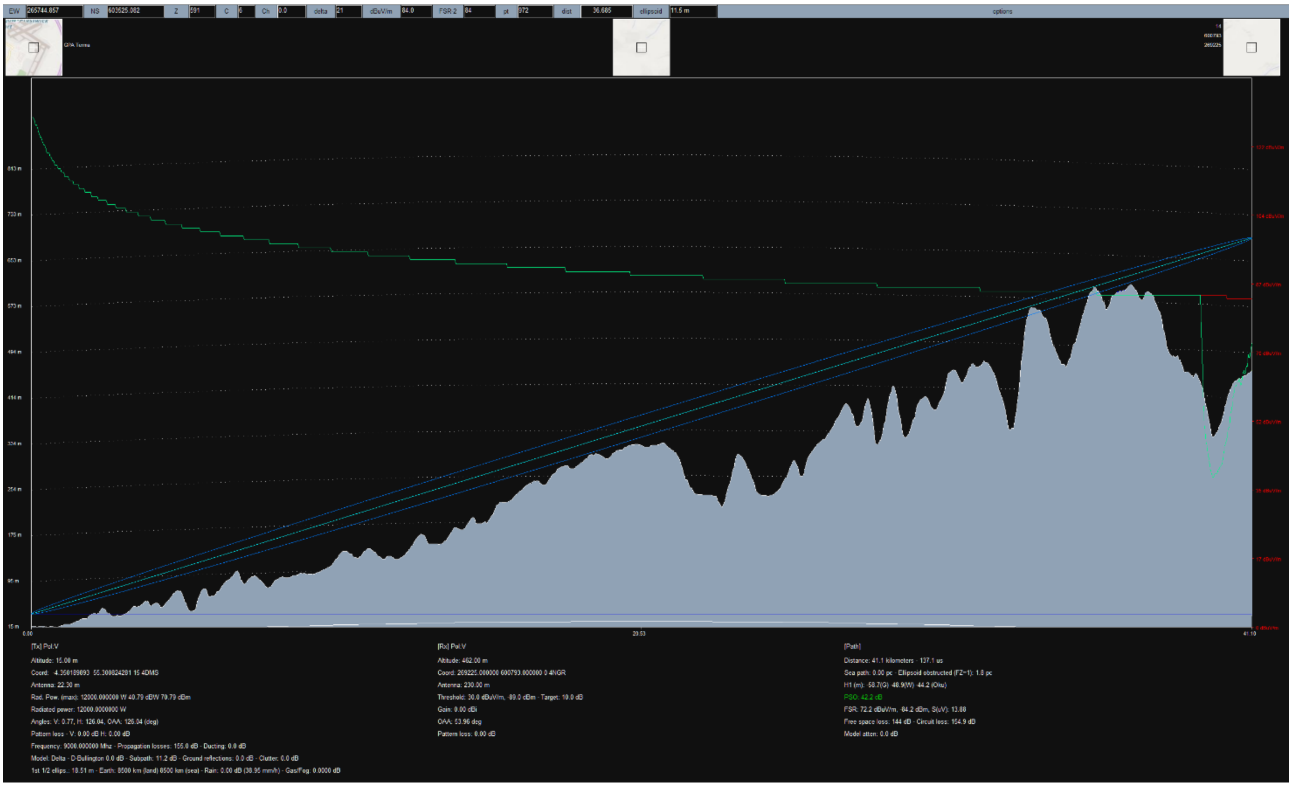
B.12. Turbine 12



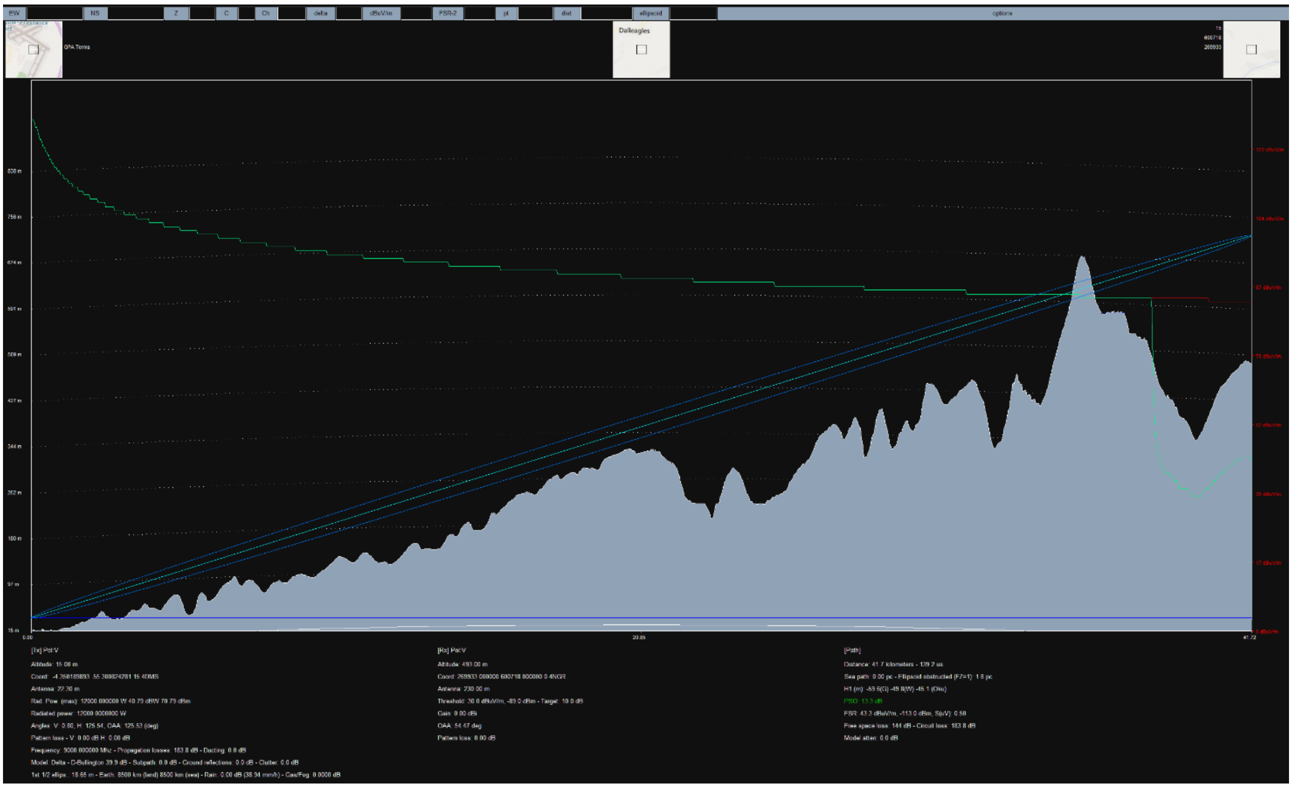
B.13. Turbine 13



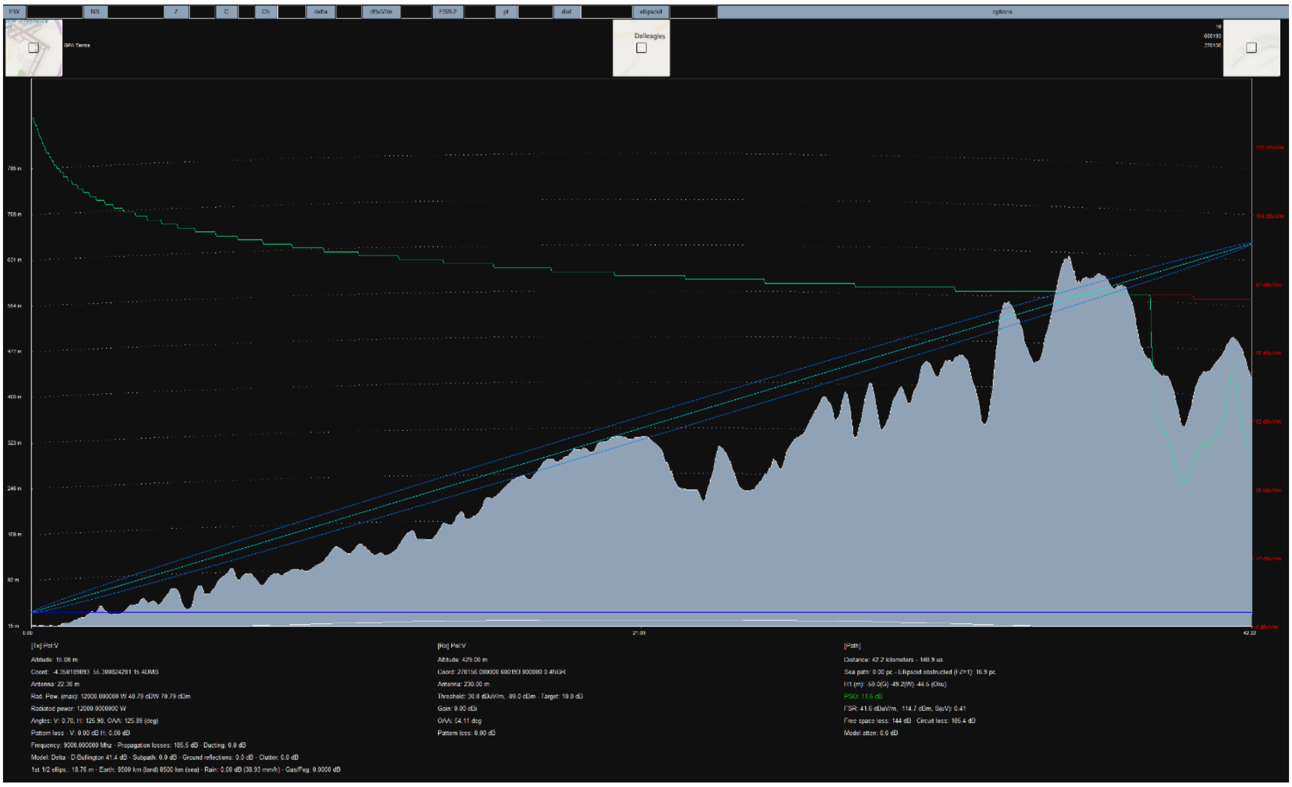
B.14. Turbine 14



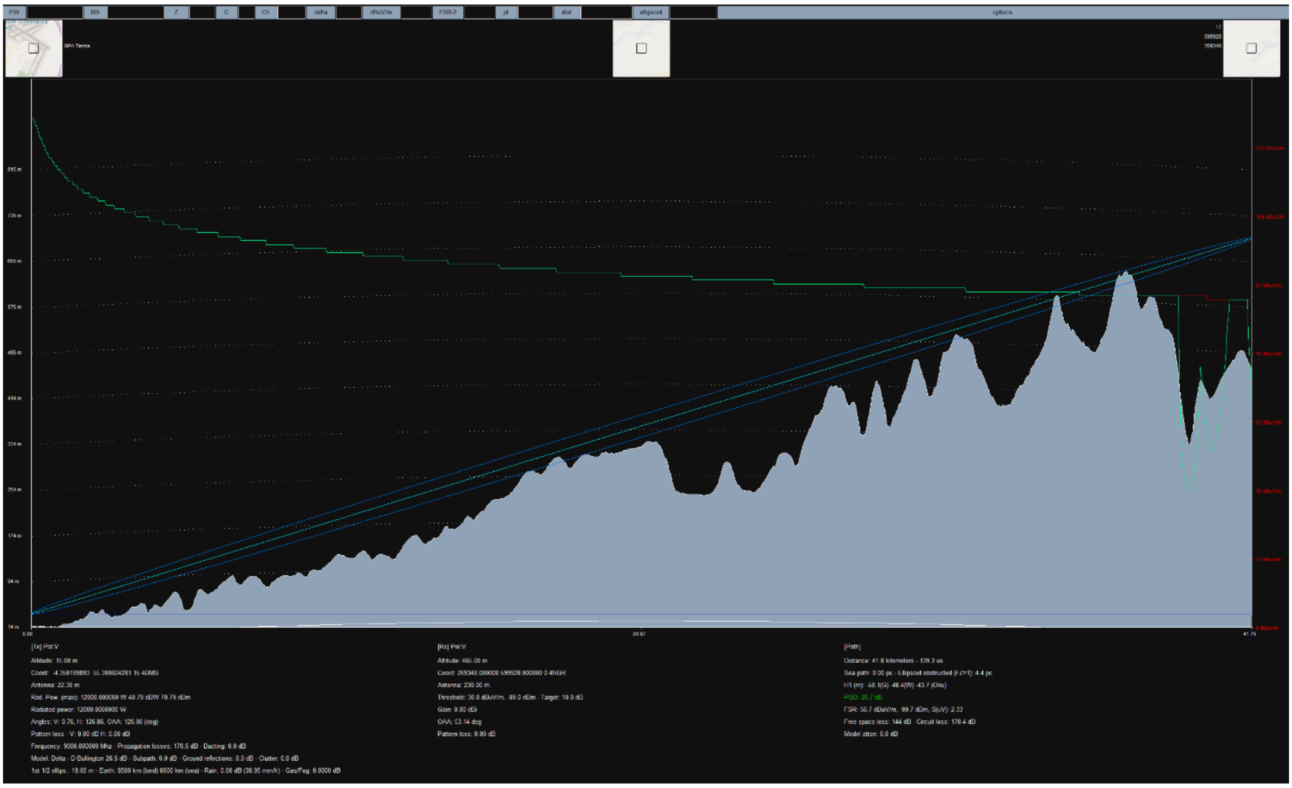
B.15. Turbine 15



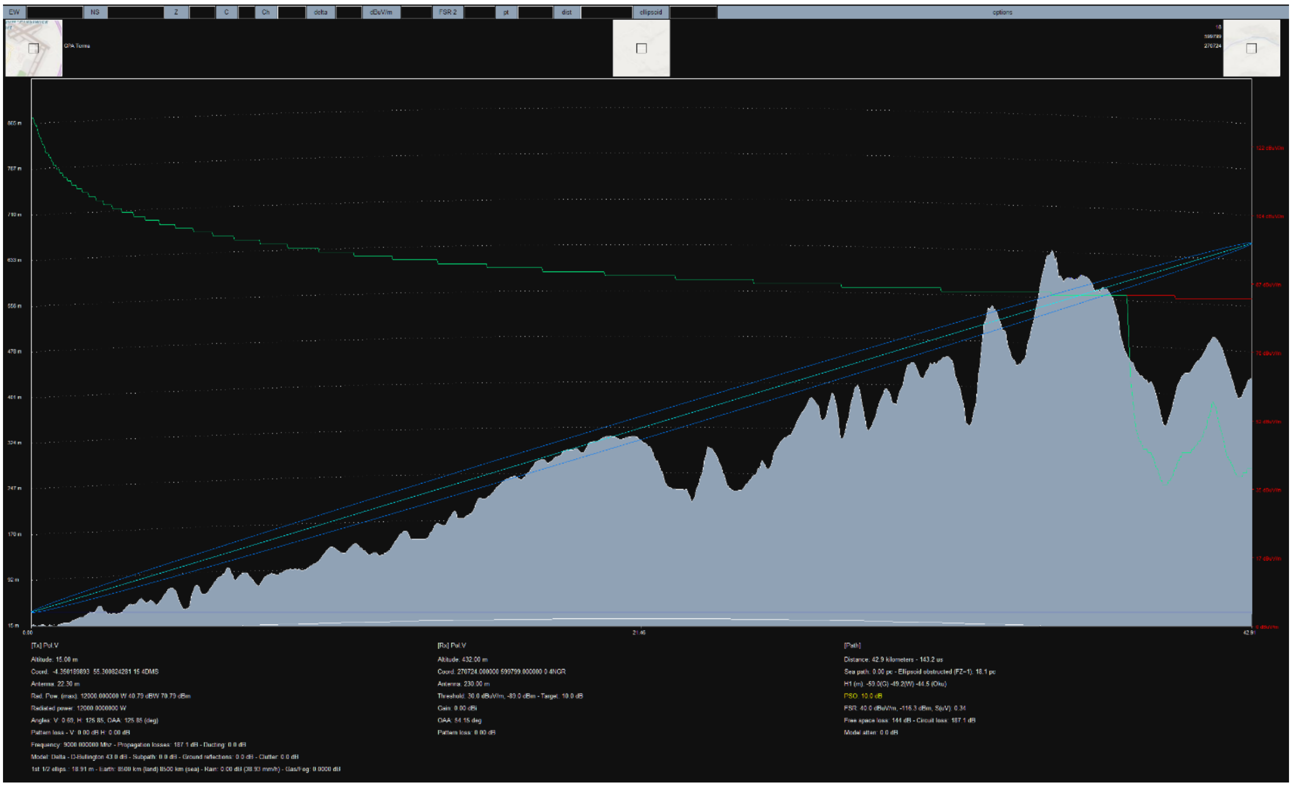
B.16. Turbine 16



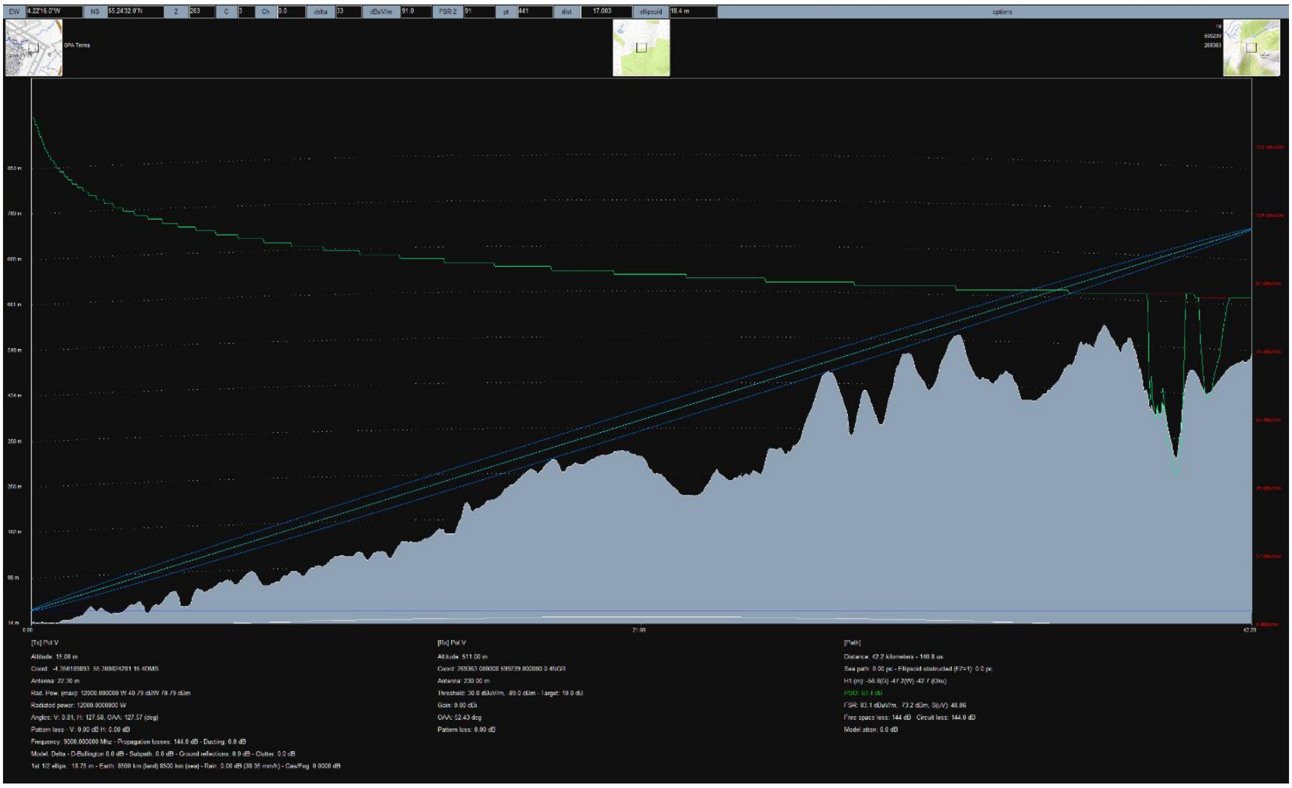
B.17. Turbine 17



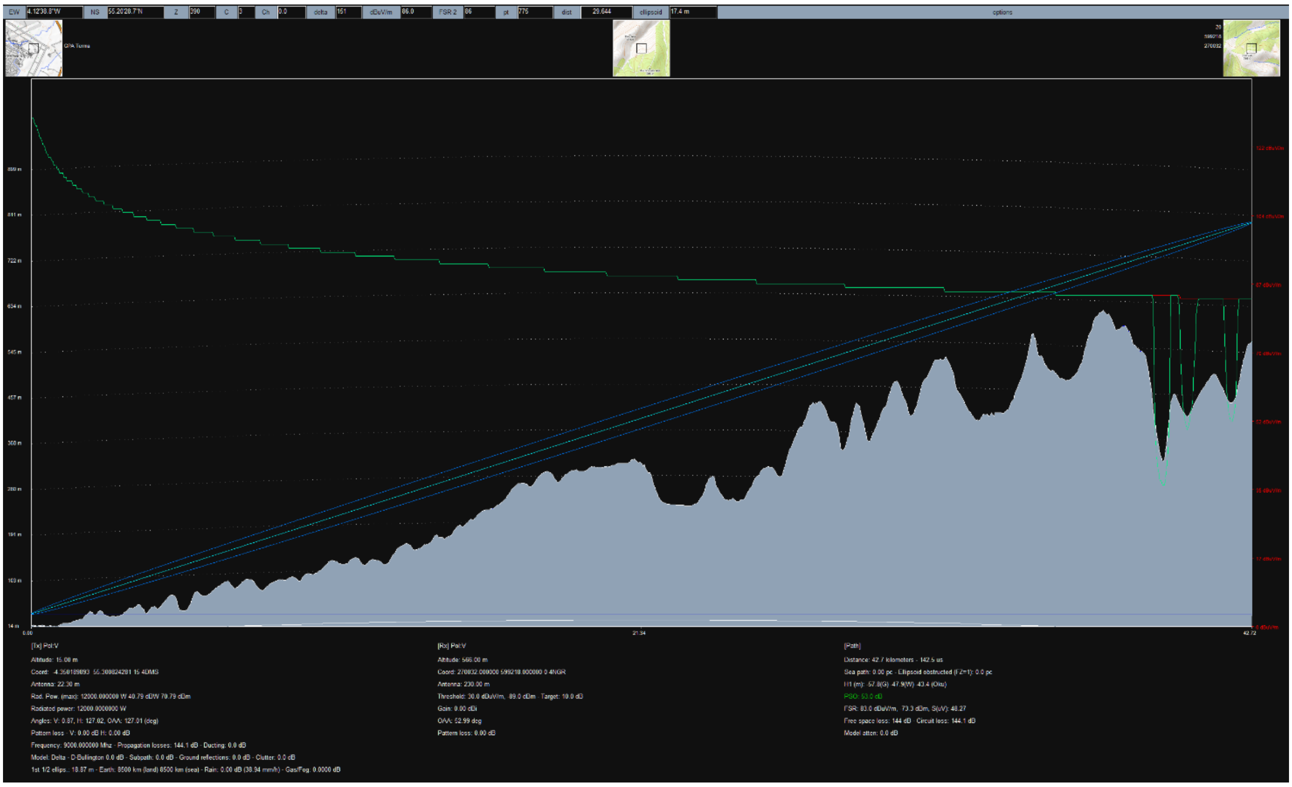
B.18. Turbine 18



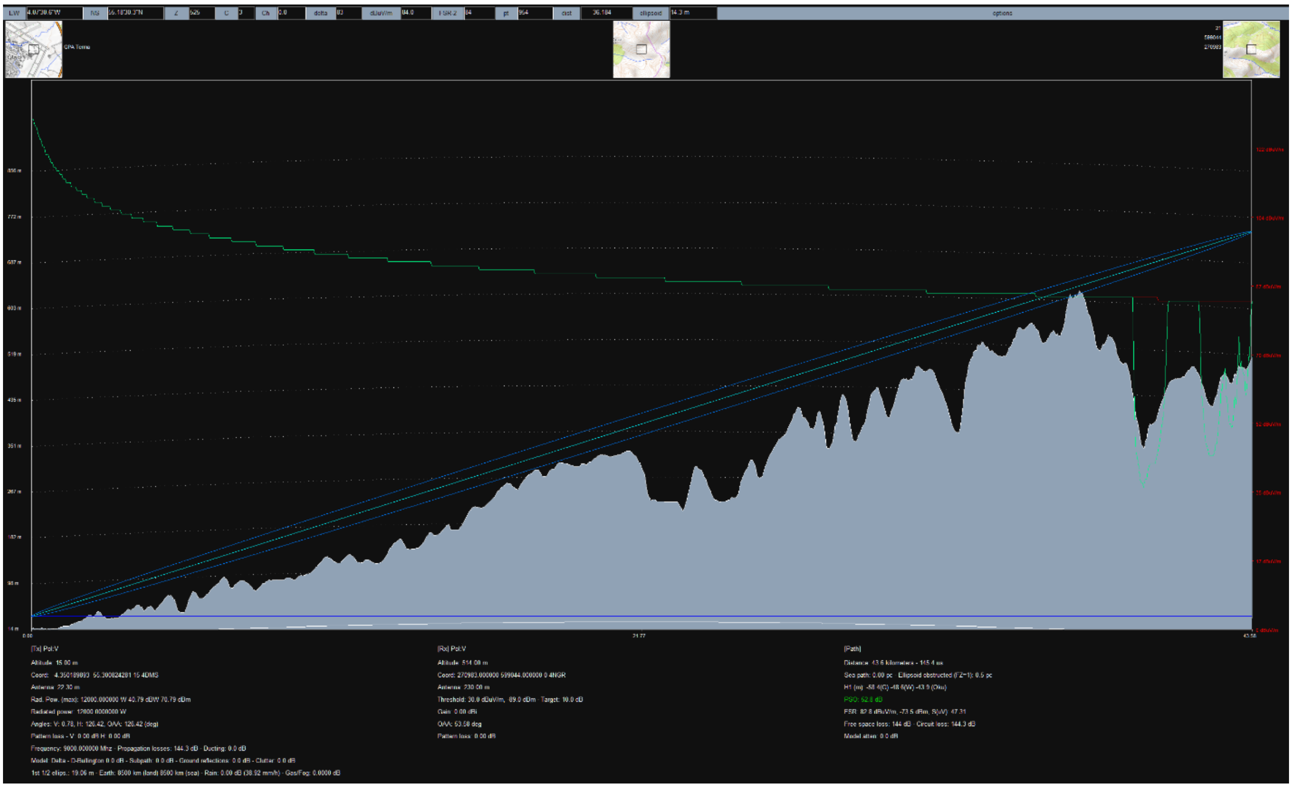
B.19. Turbine 19



B.20. Turbine 20



B.21. Turbine 21



This Page Is Intentionally Blank

ScottishPower Renewables
9th Floor
320 St Vincent Street
Glasgow
G2 5AD

T +44 (0)141 614 0451

euchanheadrenewables@scottishpower.com