ScottishPower Renewables

ACP-2023-008 Airspace Trial Plan

9/28/23

Business division

1. What this airspace trial involves

Why we are undertaking this trial?

SPR intend to install Aviation Detection Lighting System (ADLS) at several proposed windfarms to minimise the impact of aviation lighting on the visual landscape. The sites being considered for the system are located in and around the Galloway Dark Sky Park buffer zone in Southwest Scotland. NatureScot has raised concerns about the visual impact of aviation lighting in sensitive areas such as the Dark Skies Park.

Current windfarm lighting systems require red obstructon light on wind turbines to comply with CAA regulations. When lit during the hours of darkness and these can cause adverse visual effects in areas of sensitivity such as designated dark skies areas. It is expected that the use of ADLS would minimise this impact while maintaining aviation safety.

As this would be a first of type in the UK, SPR intend to undertake a trial of the technology at their existing Mark Hill windfarm in Southwest Scotland to prove the Concept of Operation. Mark Hill is situated in Class G airspace underneath the Scottish TMA and **is not a lit windfarm due to the height of the turbines.**

There is no mandate for Electronic Conspicuity (EC) carriage in Class G airspace. The Airspace Modernisation Strategy (AMS) includes mandatory EC within the next few years. The ADLS system relies upon EC primarily provided by Automatic Dependant Surveillance Broadcast (ADS-B). Until EC is mandatory in Glass G airspace, aircraft not transmitting ADS-B data will be detected by measuring the received signal strength of their radar transponder. This method of detection requires all aircraft using the airspace to be fitted with a transponder. Consequently, SPR are progressing an ACP for a Temporary Transponder Mandatory Zone (TMZ) around Mark Hill.

The results of this trial will verify the ADLS Concept of Operation and provide safety related information for the Civil Aviation Authority. The safety and verification evidence will support regulatory approval for future ADLS deployments and inform new CAA Policy and regulations.

How will we undertake the trial and what is involved?

For the trial to produce evidence in support of ADLS technology we need to collect and analyse aircraft position data from within and out with the trial area. Based on CAA guidance, SPR will identify what, if any traffic, will likely be impacted by this Temporary TMZ. Analysis that compares PSR data with SSR data, will give an indication of the number of non-EC equipped airspace users that could be affected. The trial will also involve some dedicated flight trials to enhance the data collection around ADSL performance.

The trial technology will involve the installation ADS-B receivers only **(not lights)** which will receive messages containing the aircraft's precise position and height. No positional information is broadcast from aircraft that are only transponder equipped, and estimated

range using the Received Signal Strength (RSS) is used. This is a much less accurate method of determining an aircraft position and will require the ADLS detection volume to be larger than if all aircraft had ADS-B. RSS data will be used to examine RSS range accuracy and the extent of the detection volume.

The default position for an ADLS is to have the obstruction lights switched on, with ADLS switching the obstruction lights off when aircraft are not within the pre-defined detection volume of airspace. Consequently, failure of the ADLS would result in the Obstruction lights remaining switched on to maintain aviation safety. **Once again, for this trial there will be no lights installed at Mark Hill windfarm.**

2. What the trial is aiming to investigate, prove & validate

The Operational Trial has two Principal Aims and associated objectives:

1. To confirm the System Availability and performance of the installed equipment in the environment:

- Reliability of the equipment used in the ADLS – Mean Time Between Failures
- Probability of Target detection
- Target position accuracy
- Correct determination of target type e.g. ADS-B and/or Transponder.

2. To determine the 'Lights on' occurrences and durations based on aircraft detection in a volume of airspace that maintains aviation safety by:

- Correlating target detection inside and outside the TMZ airspace volume with lights on/off
- Identifying any changes to the noise profile of aircraft within the vicinity of the TMZ
- Confirming that the ADLS will reduce the lights on duration compared with uncontrolled Obstruction Lighting.

Note: no visible lights will be 'switched on' during this trial, there will data collection only.

Inform

The trial will require a temporary TMZ to ensure that aircraft flying within it are mandated by the CAA to have a transponder. This will provide the following positional data information sources:

a) Mode S

As noted above, where ADS-B data is not available, the transponder RSS will be used to estimate the aircraft range.

b) Mode S Extended Squitter

Those aircraft fitted with an enhanced version of transponder (Mode S Extended Squitter) will also broadcast ADS-B. The ADS-B data will be used.

c) Standalone ADS-B Equipment

ADS-B data may be transmitted using standalone equipment only (i.e. no transponder) and is normally deployed in smaller aircraft. As noted above, CAA regulations do not include mandatory EC and consequently there is no associated airspace category. Therefore, in a TMZ, aircraft with the mandated basic transponder and standalone ADS-B equipment, both the RSS and ADS-B method could be used. The trial will use the ADS-B data but post trial analysis may be used for RSS range accuracy assessment.

ADLS is approved and operational in Germany. Whilst this technology is now mandated by the Luftfahrt-Bundesamt (German equivalent of the CAA), the UK CAA require independent safety assurance evidence. The Operational Trial will form part of this evidence.

SPR will initially use a 3NM detection boundary for the temporary TMZ airspace, based on the expected aircraft maximum speed in this area, Figure 2 refers. This limit will be assessed during the trial to determine the performance of the ADLS and whether the detection boundary limit will need to increase or decrease during the trial. Using modelling and data collected from the trial, the feasibility of other limits (e.g. 2.5NM and 3.5NM) will be assessed. If the trial is successful and ALDS is adopted as a solution for Reduced lighting by the Head of Airworthiness Policy and Rulemaking at CAA, it could be deployed at future, and existing windfarm developments. The ADLS may not be an appropriate solution for all developments.

Obstruction lighting provides visibility of obstacles to aircraft operating at night reducing the risk of collision. UK Standardised Rules of the Air[1] prohibit aircraft from flying lower than 500ft above the highest physical obstruction.

For the purposes of this trial, turbine A5 (see Figure 1) has a ground elevation of 227.5m and a turbine height of 110m, giving a total elevation of 337.5m (1108ft).

Calculation of the vertical limit of the airspace for the location of the operational trial, results in the following vertical boundary:

d) Highest elevation of turbine A5: 227.5m (747ft) AMSL

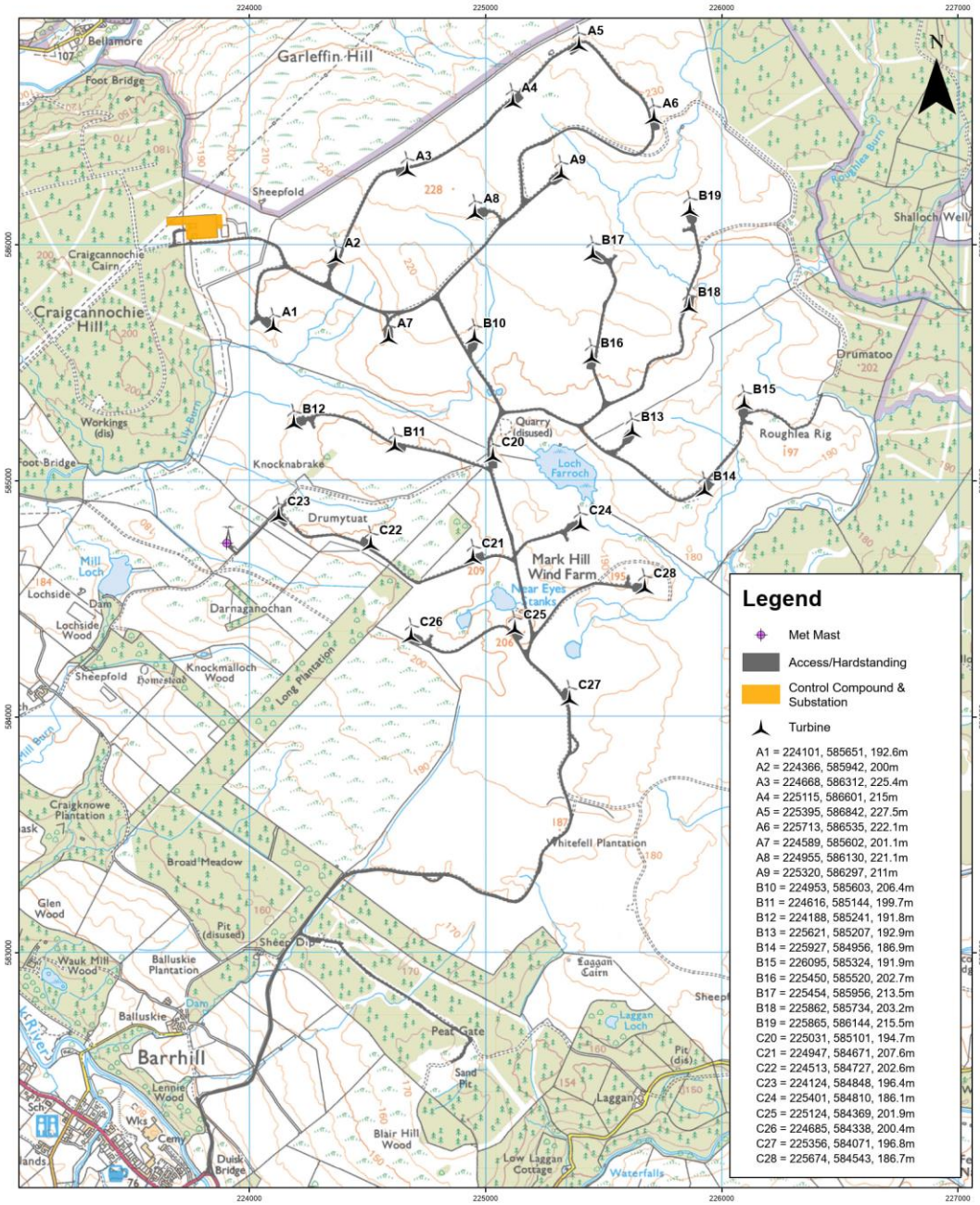
e) A5 Turbine height: 110m (361ft) AGL

f) ADLS Safety Margin: 1000ft

[1] https://www.caa.co.uk/uk-regulations/aviation-safety/basic-regulation-the-implementing-rules-and-uk-caa-amc-gm-cs/sera-standardised-rules-of-the-air/

Vertical Limit of ADLS airspace volume: 2108ft AMSL (a+b+c)

- **Rounding up to the nearest 100ft = 2200ft**



Mark Hill
Turbine Foundation Altitude

1:15,000 Scale @ A3

Rev	Date	By	Comment
A	29/06/23	MN	First Issue.

Figure	Date	Rev	Dwg No.	Datum: OSGB36 Projection:TM
1	29/06/23	A	MH-I-011	

Figure 1- Position of Highest Turbine at Mark Hill

Therefore, it is anticipated that the dimensions of the airspace for the Temporary TMZ will be 3NM from the boundary of the windfarm by 2200ft AMSL. Figure 2 below shows a schematic example of the parameters required.

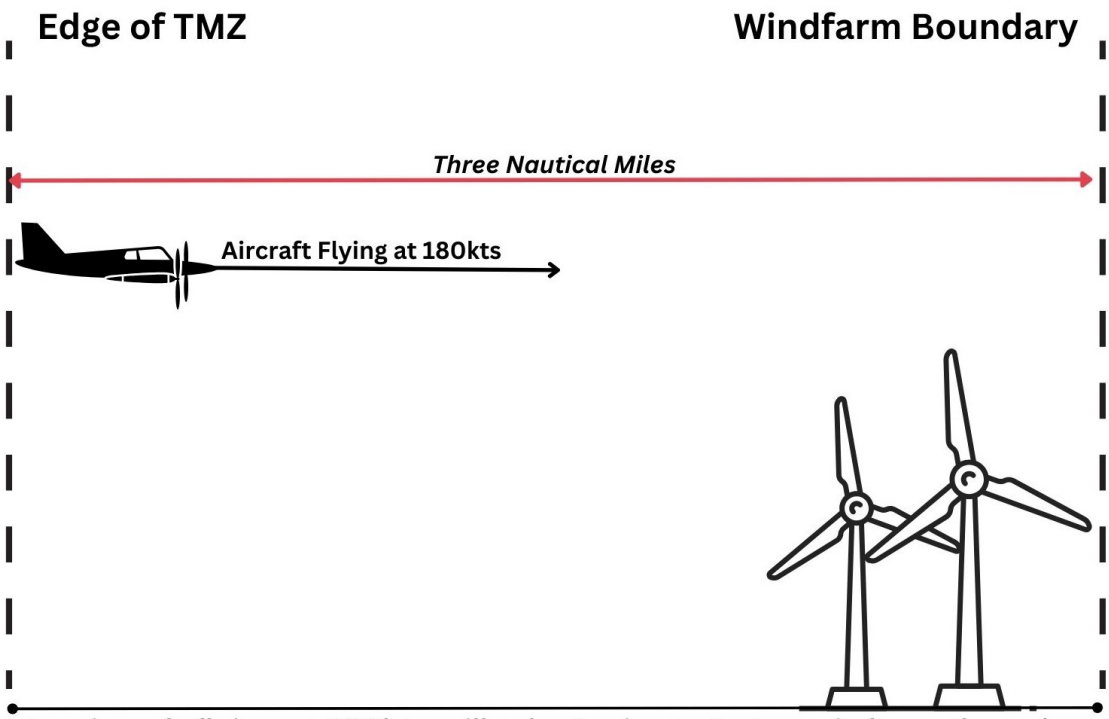


Figure 2 - Example of TMZ Parameters

Data collection will be undertaken over a proposed 6-month period and will help to verify the ADLS Concept of Operation and inform the draft guidance currently being developed by the CAA for ADLS in the UK.

The ADLS supplier will record aircraft detections and the duration of the lights on/off. SPR will verify the performance of the system using several independent means:

1. Independent ADS-B receiver to confirm the ADLS equipment identifies the same aircraft and their positions.
2. NATS En-Route Ltd (NERL) surveillance radar data providing aircraft positions and heights in the TMZ Airspace and surrounding area. This will be used to baseline ADLS performance being the 'True Position' of aircraft.

3. The NERL data will also be used to model the performance with a 2.5NM and 3.5NM horizontal limit. This will be used to provide guidance on the dimensions required for an ADLS in the UK with a supporting rationale.
4. NERL will also be providing surveillance data covering the last 5 years. The same model will be used to verify that an ADLS during this period would have maintained aviation safety while minimising the lights on period.

The defined objective of this trial is to prove, via the data collected, and SPR verification of that data, that ADLS will reduce light pollution in dark sky areas within the UK whilst maintaining aviation safety, albeit with the addition of a TMZ.

The Objectives of the ADLS Operation Trial with the associated success criteria is shown in Table 1:

AIM	OBJECTIVE	SUCCESS CRITERIA	COMMENT
Confirm the System Availability and performance	Reliability of the equipment used in the ADLS – Mean Time Between Failures	Consistent with claims in the ADLS Reliability Model.	Statistically verification would require many hours of ADLS operation at multiple sites. This assessment can only determine gross errors in equipment MTBF against that submitted by the manufacturer.
	Probability of Target detection	Pd>90%	Value aligns with recognised values for surveillance systems and used in CAA Regulations.
	Target position accuracy	ADS-B < 300m, 100ft Transponder <5NM	
	Correct determination of target type e.g. ADS-B and/or Transponder	>99.99%	
	Option Evaluate the ADS-B position accuracy for aircraft with a standalone ADS-B equipment and basic transponder.		CAA do not mandate ADS-B equipment must meet a minimum specification. Therefore, postion data integrity may not be assured.

Determine the Lights on occurrences based on aircraft position in a volume of airspace that maintains aviation safety	Correlate target detection inside and outside Airspace volume with lights-on/off	100% correlation when aircraft are present in the detection airspace volume.	For aviation safety lights must always be on when aircraft are within the detection volume. Aviation safety is maintained when the system default is lights on.
	Introduction of a TMZ demonstrates minimal impact of normal operations in the area	Normal operations are maintained during hours of TMZ operation	Traffic study will be carried out using recorded data and live data
	No adverse effect on noise profile of aircraft across the area.	Noise analysis will demonstrate negligible change to noise	
	The ADLS will reduce the lights-on duration compared with uncontrolled Obstruction Lighting.	>25% reduction in lights on compared with uncontrolled Obstruction Lighting.	

The Objectives of the ADLS Operational Trial modelling with the associated success criteria is shown in Table 2 below:

OBJECTIVE	DESCRIPTION	SUCCESS CRITERIA	COMMENT
Operational Trial Data			
1.	Separate ADS-B receiver to confirm the manufacturer equipment identifies the same aircraft and their positions.	>99.99%	Assumes all ADS-B antennas are collocated.
2.	NERL surveillance radar data providing aircraft positions and heights in the TMZ Airspace and surrounding area. This will be used to baseline ADLS performance being the 'True Position' of aircraft.	ADS-B < 300m, 100ft Transponder only < 5NM	
Modelling using NERL data			
3.	The NERL data will also be used to model the performance with a 2.5NM and 3.5NM horizontal limit. This will be used to verify the EASA guidance to use 3.0NM.	As Operational Trial	
4.	NERL will also be analysing surveillance data covering the last 5-years. The same model will be used to verify that an ADLS during this period would have maintained aviation safety while minimising the lights-on period.	As Operational Trial	

1. Noise

The CAA held a guidance meeting with SPR and Cyrrus to answer some questions regarding the noise analysis required for the trial. SPR have asked NERL to analyse radar data (primary/secondary radar, recent and historical data) from Lowther Hill radar to determine traffic levels and routes (a traffic survey). This will set the baseline for any noise analysis.

The CAA advised that they would need to see evidence of the potential impacts on any GA/Military transits. Following an analysis of the traffic data, SPR will produce an appropriately scaled noise assessment to support the trial and its output.

Based on the CAA guidance, SPR will identify what, if any traffic, will likely be impacted by this Temporary TMZ and any changes to the baseline traffic patterns and resulting impact to the noise footprint identified.

Flight Trials

SPR will work with an aircraft operator with experience in carrying out flight trials, to undertake dedicated flight trials. These flight trials will be initially guided by similar trials undertaken in the Netherlands by the technical supplier of ADLS to SPR, but may use a different methodology to reflect the airspace environment and UK CAA regulations.

For the flight trials, the operator will depoy an aircraft which is registered for commercial operation and equipped with the following minimum equipment:

- Transponder with the capability to send Mode A/C and Mode-S/ES (ADS-B with GPS data SIL >=1)
- Programable GPS Navigation system to plan and follow the planned flight path.
- GPS logger e.g. LX-Nano of FLARM device with log interval set to 1 sec (For future use in EC data analysis)
- Radio (with dual watch function if possible)
- Altimeter

2. Details of flight trials

The flight trial aircraft will undertake a ‘pizza slice’ activities from 3nm into the centre of the TMZ along with several tangential slices on the 4nm, 3.5nm and 2nm distances, as shown on the map below: (insert some sort of map here showing the way the ac will fly)

The output from the flight trial aircraft will be provided in a similar format shown below in Figure 3 , which represents a previous flight trial activity undertaken in the Netherlands:

line #	Timestamp merged and filtered data	GPS Latitude / ADLS status change	GPS Longitude	Hight HAE	Distance BD7 receiver	Comment
1	2023-05-16T10:13:34.254: INFORMATION	ADLS LIGHTS ON				
2	2023-05-16T10:13:35.00000	51.5220N	3.7181E	152m	12.21km	Distance when status changes
3	2023-05-16T10:18:39.00000	51.5596N	3.8996E	337m	15.44km	Distance when status changes
4	2023-05-16T10:18:40.044: INFORMATION	ADLS LIGHTS OFF				
5		ADLS LIGHTS OFF				
6	2023-05-16T10:20:10.302: INFORMATION	ADLS LIGHTS ON				
7	2023-05-16T10:20:11.00000	51.5783N	3.9524E	268m	17.86km	Distance when status changes
8	2023-05-16T10:25:23.00000	51.6180N	4.1376E	349m	29.66km	Distance when status changes
9	2023-05-16T10:25:24.100: INFORMATION	ADLS LIGHTS OFF				
10		ADLS LIGHTS OFF				
11	2023-05-16T10:35:54.740: INFORMATION	ADLS LIGHTS ON				
12	2023-05-16T10:35:55.00000	51.6361N	3.8397E	410m	9.07km	Distance when status changes
13	2023-05-16T10:39:15.00000	51.6371N	3.7094E	377m	0.62km	Flyover
14	2023-05-16T10:44:39.00000	51.7469N	3.7959E	379m	14.16km	Distance when status changes
15	2023-05-16T10:44:40.053: INFORMATION	ADLS LIGHTS OFF				
16		ADLS LIGHTS OFF				
17	2023-05-16T11:18:29.339: INFORMATION	ADLS LIGHTS ON				
18	2023-05-16T11:18:31.00000	51.6398N	3.5636E	55m	10.04km	Distance when status changes
19	2023-05-16T11:23:27.00000	51.6351N	3.6997E	370m	0.71km	Flyover
20	2023-05-16T11:28:47.00000	51.5868N	3.5243E	357m	13.66km	Distance when status changes
21	2023-05-16T11:28:48.991: INFORMATION	ADLS LIGHTS OFF				
22		ADLS LIGHTS OFF				
23	2023-05-16T11:28:49.995: INFORMATION	ADLS LIGHTS ON				
24	2023-05-16T11:28:51.00000	51.5863N	3.5219E	357m	13.84km	Distance when status changes
24a	2023-05-16T11:32:47.00000	51.5527N	3.3870E	360m	23.88km	added with V2
24b	2023-05-16T11:32:48.400: INFORMATION	ADLS LIGHTS OFF				
		ADLS LIGHTS OFF				
24c	2023-05-16T11:57:42.429: INFORMATION	ADLS LIGHTS ON				
24d	2023-05-16T11:57:43.00000	51.4553N	3.6686E	545m	19.80km	added with V2
25	2023-05-16T12:05:59.00000	51.6261N	3.7134E	851m	0.70km	limit 867m QNE/1014 HAE
26	2023-05-16T12:13:59.00000	51.7323N	3.9684E	837m	21.12km	below activation zone hight
27	2023-05-16T12:14:01.929: INFORMATION	ADLS LIGHTS OFF				
28		ADLS LIGHTS OFF				
29	2023-05-16T12:30:29.490: INFORMATION	ADLS LIGHTS ON				
30	2023-05-16T12:30:31.00000	51.6642N	3.7906E	839m	6.72km	below activation zone hight
31	2023-05-16T12:32:55.00000	51.6311N	3.7076E	817m	0.09km	limit 867m QNE/1014 HAE
32	2023-05-16T12:38:43.00000	51.5541N	3.5143E	799m	15.95km	below activation zone hight
33	2023-05-16T12:38:44.823: INFORMATION	ADLS LIGHTS OFF				
34		ADLS LIGHTS OFF				
35	2023-05-16T12:43:54.645: INFORMATION	ADLS LIGHTS ON				
36	2023-05-16T12:43:55.00000	51.5657N	3.6423E	499m	8.64km	Distance when status changes
37	2023-05-16T12:45:55.00000	51.5745N	3.7197E	537m	6.40km	
38	2023-05-16T12:54:47.00000	51.6141N	4.0785E	530m	25.62km	Distance when status changes
39	2023-05-16T12:54:50.046: INFORMATION	ADLS LIGHTS OFF				
40		ADLS LIGHTS OFF				
41	2023-05-16T13:18:50.130: INFORMATION	ADLS LIGHTS ON				
42	2023-05-16T13:18:51.00000	51.5611N	4.1373E	308m	30.64km	Distance when status changes
43	2023-05-16T13:19:55.00000	51.5570N	4.0974E	305m	28.12km	Distance when status changes
44	2023-05-16T13:19:55.327: INFORMATION	ADLS LIGHTS OFF				
45		ADLS LIGHTS OFF				
46	2023-05-16T13:21:25.624: INFORMATION	ADLS LIGHTS ON				
47	2023-05-16T13:21:27.00000	51.5537N	4.0406E	295m	24.52km	Distance when status changes
48	2023-05-16T13:22:23.00000	51.5523N	4.0066E	306m	22.41km	Distance when status changes
49	2023-05-16T13:22:26.882: INFORMATION	ADLS LIGHTS OFF				
50		ADLS LIGHTS OFF				
51	2023-05-16T13:22:45.923: INFORMATION	ADLS LIGHTS ON				
52	2023-05-16T13:22:47.00000	51.5518N	3.9918E	298m	21.49km	Distance when status changes
53	2023-05-16T13:23:47.00000	51.5500N	3.9550E	294m	19.30km	Distance when status changes
54	2023-05-16T13:23:47.137: INFORMATION	ADLS LIGHTS OFF				
55		ADLS LIGHTS OFF				
56	2023-05-16T13:24:10.207: INFORMATION	ADLS LIGHTS ON				
57	2023-05-16T13:24:11.00000	51.5506N	3.9399E	287m	18.35km	Distance when status changes
58	2023-05-16T13:29:07.00000	51.5488N	3.7576E	142m	9.81km	Flyover
59	2023-05-16T13:32:19.00000	51.5127N	3.7299E	-78m	13.31km	Distance when status changes
60	2023-05-16T13:33:41.042: INFORMATION	ADLS LIGHTS OFF				

Figure 3 – Example of Aircraft Flight Trial output

3. Stakeholder Engagement

Phase 1 – Targeted engagement prior to agreement for trial

Relevant aviation stakeholders have been identified, as per CAP 1616 para 317, and targeted engagement has been undertaken, on the operational viability of the trial. See Annex A for the Chronology of Engagement.

We determined that virtual stakeholder meetings would be undertaken, where face to face meetings were not feasible for some stakeholders. We scheduled both daytime & evening virtual meetings, along with daytime face to face meetings for several different days/evenings over several months. The team visited some stakeholders in person, where this was requested, and other meetings were held at SPR HQ in Glasgow.

Engagement materials took the form of a PowerPoint presentation, see Annex B, accompanied by verbal explanations. Comprehensive note taking was completed at each session and feedback forms sent out to all attendees. These are attached within the Chronology of Engagement Document at Annex A.

A HAZID session took place on 21 June 2023 which identified that the temporary TMZ will not present an unacceptable safety risk. This was also confirmed in the subsequent Safety Assurance work. In fact, it is argued that there is no or negligible change in the safety risk during the trial period.

4. Start and End date of the Temporary TMZ Trial

The trial is planned to start on 28 December 2023 and run for 6 months until 28 June 2024. Installation of the equipment will begin at the end of October 2023 for this timeline to be met.

5. Desired Outcomes

- The capability of the ADLS system i.e. reliability, sensitivity, latency, accuracy.
- Recommendations for the buffers and heights together with the evidence to support the potential permanent TMZ at windfarm sites.
- Draft guidance notes for the CAA and Scottish Government Aviation Lighting Group.
- Updated Concept of Operation documentation, including safety information.