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Project No: 315148

Building 7, Shoreham Technical Centre - Glint & Glare Assessment

Prepared for:

Ricardo UK Ltd

Contents Amendment Record

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Acknowledgement

This report has been prepared for the sole and exclusive use of Ricardo UK Ltd (Ricardo) in accordance with the scope of work presented in Mabbett & Associates Ltd (Mabbett) Letter Agreement (315148/LH/030524/2.0), dated 03 May 2024. This report is based on information and data collected by Mabbett. Should any of the information be incorrect, incomplete or subject to change, Mabbett may wish to revise the report accordingly.

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Section 1.0: Introduction

1.1 Introduction

Ricardo UK Ltd are proposing to install roof-mounted solar arrays on the roof of an existing building (Building 7) at Shoreham Technical Centre, Old Shoreham Road, Shoreham-By-Sea, BN43 5FG.

Ricardo has requested that Mabbett prepare a glint and glare assessment to assess the impact of the proposed development on Brighton City Airport.

The report presents the findings of the Glint and Glare Assessment undertaken for the proposed solar PV development.

1.2 Glint & Glare

Reflectivity refers to light that is reflected off surfaces (e.g. glazed surfaces or areas of metal cladding). The potential effects of reflectivity are glint and glare. The US Federal Aviation Administration's (FAA) *'Technical Guidance for Evaluating Selected Solar Technologies on Airports'* provides the following glint and glare definitions:

- Glint – *"a momentary flash of bright light"*
- Glare – *"a continuous source of bright light"*

These present an ocular hazard to light sensitive receptors such as road users, train drivers, occupants of nearby dwellings, pilots, and air-traffic control personnel, as they can cause a brief, temporary or permanent eye damage (ocular impact categories and significance further discussed in Section 4.0).

In general, solar PV systems are constructed of dark, light-absorbing material designed to maximise light adsorption and minimise reflection. However, the glass surfaces of solar PV systems also reflect sunlight to varying degrees throughout the day and year, based on the incidence angle of the sun relative to ground-based receptors. Lower incidence angles amount to increased reflection.

As such, the amount of light reflected off a solar PV panel surface or an array of solar panels depends on a variety of factors to include:

- The amount of sunlight hitting the surface;
- Its surface reflectivity;
- Its geographic location;
- Time of the year;
- Cloud coverage; and
- Panel orientation.

1.3 Scope of Work

Based on definitions and factors described in Section 1.2 and in combination with available guidance and good practice recommendations, a desk-based evaluation was undertaken to evaluate the potential to experience the effects of glint and glare towards Brighton City Airport. A solar glare analysis tool was utilised to model the solar PV arrays and examine the times of the year and days such effects may occur, as well as the magnitude of their impact. The results of this study were subsequently interpreted, and appropriate recommendations made.

Brighton City Airport has set out additional requirements with regard to the potential impact of glint and glare. These are as follows:

1. Receptor points in left-hand visual circuits at 1100feet for the runways 02/20 asphalt and grass.
2. Receptor points in a helicopter training visual circuit flown to the west of runway 02/20. Climb on a track parallel to the departure lane from the main runway. When crossing the railway line, turn right 10 degrees. Continue to the coast and turn north-east for the downwind leg. Continue climb to 800 FT QNH, to be level by the football training ground. After crossing the A27, descend to 600 FT QNH to be level before turning east. Upon reaching the River Adur, turn south towards the aerodrome and make the approach to HTA 'W'.

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A visual circuit is a specified path in which an aircraft flies visually in the airspace around an aerodrome.

Section 4.0 provides further details on methodology followed to complete this study.

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Section 2.0: Development Characteristics

2.1 Site Description

The site (centred at National Grid Reference, NGR, 520482, 106095) is located at Shoreham Technical Centre (Building 7), Old Shoreham Road, Shoreham-By-Sea, BN43 5FG. It is bounded to the north, west and south by additional Shoreham Technical Centre buildings, and to the east by the river Adur.

The site is located approximately 500m northeast of Brighton City Airport. The site location is shown in Figure 2.1 below in **red.**

Figure 2.1: Site Location



Imagery © Google 2024

2.2 Proposed Development

The proposed solar development comprises of a roof-mounted arrays installed on the roof of the existing building (Building 7) at Shoreham Technical centre.

The modelled PV module orientation and inclination, as well as PV panel height above ground, is summarised in the below table[1]:

PV Array	Orientation (Azimuth)[2]	Panel Tilt	Height above ground
Array 1	98° & 188°	10°	10.29m

Each panel will be coated in an anti-reflective coating. For the purpose of this assessment the PV panels are modelled as *'smooth glass with Anti-Reflective Coating (ARC)'*.

[1] Based on information provided by Ricardo.
[2] North referenced at 0°.

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The site plan and proposed model layout is shown in Figure 2.2 and Figure 2.3 below. For the purposes of modelling, the roof layout has been simplified.

Figure 2.2: Proposed Roof Plan (Extract from Roof Level(s) MEP Plant Photovoltaic Layout)

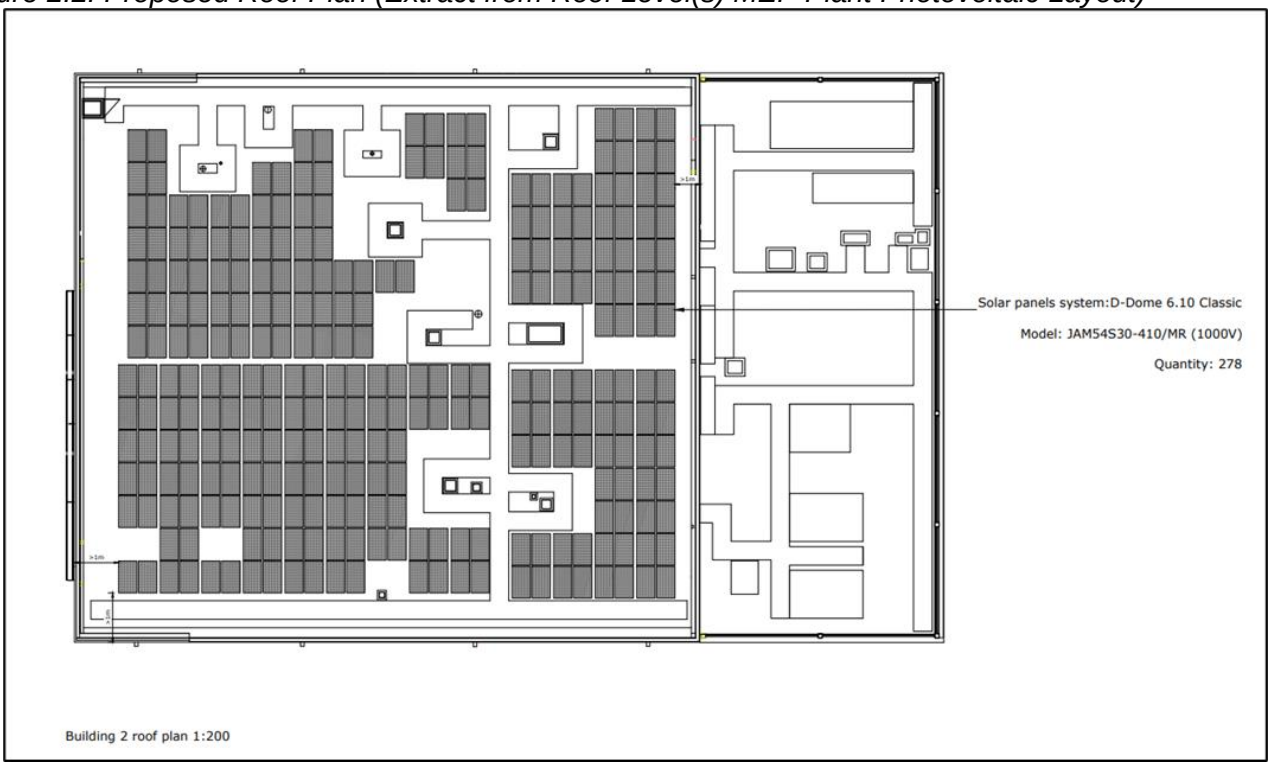

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Figure 2.3: Modelled PV Array



Imagery © 2024 Google

Section 3.0: Legislation & Guidance

3.1 Planning Guidance

3.1.1 The Town and Country Planning, (General Permitted Development) (England) Order

The Town and Country Planning, (General Permitted Development) (England) Order 2015[3] states that a written application from the developer to the local planning authority must be made before development has commenced.

With regard to potential glare from solar panels, it states:

> *"… development is permitted subject to the condition that before beginning the development the developer must apply to the local planning authority for a determination as to whether the prior approval of the authority will be required as to the design or external appearance of the development, in particular the impact of glare on occupiers of neighbouring land …"*

The term 'neighbouring land' is not defined within the legislation and there is not a standard definition. The request for glare assessment may be determined by local authority following consultation with relevant stakeholders. Relevant stakeholders for glare assessment commonly include aviation safeguarding teams, Network Rail, highways and local residents of neighbouring dwellings.

3.1.2 National Planning Practice Guidance

In the absence of specific guidance on roof-mounted solar development, the National Planning Practice Guidance for *'Renewable and Low Carbon Energy'*[4] dictates the following with respect to large-scale solar PV developments and glint and glare:

> *"The deployment of large-scale solar farms can have a negative impact on the rural environment, particularly in undulating landscapes. However, the visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively.*
>
> *Particular factors a local planning authority will need to consider include:*
>
> - *…the proposal's visual impact, the effect on landscape of glint and glare (see guidance on landscape assessment) and on neighbouring uses and aircraft safety;*
> - *the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun;…*
> - *great care should be taken to ensure heritage assets are conserved in a manner appropriate to their significance, including the impact of proposals on views important to their setting. As the significance of a heritage asset derives not only from its physical presence, but also from its setting, careful consideration should be given to the impact of large-scale solar farms on such assets. Depending on their scale, design and prominence, a large-scale solar farm within the setting of a heritage asset may cause substantial harm to the significance of the asset;*
> - *the potential to mitigate landscape and visual impacts through, for example, screening with native hedges;…*
>
> *The approach to assessing cumulative landscape and visual impact of large scale solar farms is likely to be the same as assessing the impact of wind turbines. However, in the case of ground mounted solar panels it should be noted that with effective screening and appropriate land topography the area of a zone of visual influence could be zero."*

[3] https://www.legislation.gov.uk/uksi/2015/596/pdfs/uksi_20150596_en.pdf
[4] https://www.gov.uk/guidance/renewable-and-low-carbon-energy

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3.1.3 National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)[5] sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure.

The above policy is applicable to significant renewable energy infrastructure (i.e. solar photovoltaic >50 MW in England, where MW is measured as alternating current). However, the principles may be extended to infrastructure <50MW.

Sections 2.10.27 and 2.10.102-2.10.106 outlines the potential impact of glint and glare that the applicants may consider:

> *"2.10.27 Utility-scale solar farms are large sites that may have a significant zone of visual influence. The two main impact issues that determine distances to sensitive receptors are therefore likely to be visual amenity and glint and glare. These are considered in Landscape, Visual and Residential Amenity (paragraphs 3.10.84- 3.10.92) and Glint and Glare (paragraphs 3.10.93 – 3.10.97) impact sections below."*
>
> *…*
>
> *2.10.102 Solar panels are specifically designed to absorb, not reflect, irradiation[6]. However, solar panels may reflect the sun's rays at certain angles, causing glint and glare. Glint is defined as a momentary flash of light that may be produced as a direct reflection of the sun in the solar panel. Glare is a continuous source of excessive brightness experienced by a stationary observer located in the path of reflected sunlight from the face of the panel. The effect occurs when the solar panel is stationed between or at an angle of the sun and the receptor.*
>
> *2.10.103 Applicants should map receptors to qualitatively identify potential glint and glare issues and determine if a glint and glare assessment is necessary as part of the application.*
>
> *2.10.104 When a quantitative glint and glare assessment is necessary, applicants are expected to consider the geometric possibility of glint and glare affecting nearby receptors and provide an assessment of potential impact and impairment based on the angle and duration of incidence and the intensity of the reflection.*
>
> *2.10.105 The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and design. This may need to account for 'tracking' panels if they are proposed as these may cause differential diurnal and/or seasonal impacts.*
>
> *2.10.106 When a glint and glare assessment is undertaken, the potential for solar PV panels, frames and supports to have a combined reflective quality may need to be assessed, although the glint and glare of the frames and supports is likely to be significantly less than the panels."*

Sections 2.10.134-2.10.136 outlines the potential mitigations for glint and glare impacts that the applicants may consider:

> *"2.10.134 Applicants should consider using, and in some cases the Secretary of State may require, solar panels to comprise of (or be covered with) anti-glare/anti-reflective coating with a specified angle of maximum reflection attenuation for the lifetime of the permission.*
>
> *2.10.135 Applicants may consider using screening between potentially affected receptors and the reflecting panels to mitigate the effects.*
>
> *2.10.136 Applicants may consider adjusting the azimuth alignment of or changing the elevation tilt angle of a solar panel, within the economically viable range, to alter the angle of incidence. In*

[5] https://assets.publishing.service.gov.uk/media/655dc352d03a8d001207fe37/nps-renewable-energy-infrastructure-en3.pdf

[6] Most commercially available solar panels are designed with anti-reflective glass or are produced with anti-reflective coating and have a reflective capacity that is generally equal to or less hazardous than other objects typically found in the outdoor environment, such as bodies of water or glass buildings.

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practice this is unlikely to remove the potential impact altogether but in marginal cases may contribute to a mitigation strategy."

Sections 2.10.158-2.10.159 outlines further detail on the potential glint and glare impacts that the Secretary of State may consider as part of their decision making:

"2.10.158 Solar PV panels are designed to absorb, not reflect, irradiation. However, the Secretary of State should assess the potential impact of glint and glare on nearby homes, motorists, public rights of way, and aviation infrastructure (including aircraft departure and arrival flight paths).

2.10.159 Whilst there is some evidence that glint and glare from solar farms can be experienced by pilots and air traffic controllers in certain conditions, there is no evidence that glint and glare from solar farms results in significant impairment on aircraft safety. Therefore, unless a significant impairment can be demonstrated, the Secretary of State is unlikely to give any more than limited weight to claims of aviation interference because of glint and glare from solar farms."

3.2 Aviation Guidance

3.2.1 UK Civil Aviation Authority Guidance

3.2.1.1 Interim Solar PV Systems Guidance

The UK Civil Aviation Authority (CAA) issued interim guidance relating to solar PV systems on 17 December 2010 but this was withdrawn on 7 September 2012. The guidance is provided in Appendix A.

In general, the interim guidance recommends that solar PV developments in the vicinity of or within an aerodrome's boundaries should provide safety assurance documentation (e.g. glint and glare assessment) regarding the full potential impact of the proposed installation on aviation interests, as part of the relevant planning application. It is further suggested that this information should be consulted with the CAA, particularly if the proposed development is within aerodrome boundaries, and during the installation process the developer should liaise with the affected aerodrome. Beyond these recommendations, no specific methodology or frame of reference are defined for assessing the impact of glint and glare on aviation infrastructure.

3.2.1.2 Combined Aerodrome Safeguarding Team Aerodrome Safeguarding Guidance Note

In July 2023, guidance was published by both the 'Technical focus group for renewable energy developments' and 'General Aviation focus group' as part of the Combined Aerodrome Safeguarding Team (CAST), supported by the CAA. CAST is a forum for aerodrome safeguarding stakeholders with representatives from government organisations, aviation and the private sector. The content of the guidance note is intended to provide guidance only and does not necessarily constitute the position of CAST members. This guidance note aims to provide safeguarding advice in relation to solar photovoltaic developments.

Section 2 'Safety Considerations' outlines the following safety considerations that must be assessed for the design of the planned solar photovoltaic development. Points 1 and 2 are relevant to glare assessment:

- *"ATS personnel – The control tower (if applicable) is the most important location for visual surveillance across an aerodrome for monitoring operations on the ground as well as in the air. It is therefore of critical importance that the development of solar photovoltaic developments does not significantly hinder the view from a control tower's visual control room (VCR). This may be from redesigning the layout and design of the proposed solar development to avoid glare from the solar panels or by avoiding the physical blocking of key viewpoints.*
- *Pilot – A pilot's ability to safely navigate the airspace around an aerodrome is paramount. A pilot is required to look for other aircraft and obstructions on the ground, as well as navigate towards a runway or reference points. This applies to both pilots of fixed wing aircraft and helicopters in the air, and sometimes on the ground. The standard operations that should be considered are:*
    - *pilots on approach*
    - *pilots in a visual circuit*
    - *pilots on the ground (departing and taxiing aircraft).*

  …"

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Section 3.1 ‘Safety impacts - Glint & Glare’ states:
“A key safety concern when considering a solar photovoltaic panel development on- or off-aerodrome is related to the reflection of sunlight off the photovoltaic panels commonly referred to as glint and glare.
‘Glint and glare’ is the general term used to describe the reflection of sunlight from a reflective surface, typically one that is capable of producing specular solar reflections. The definition of glint and glare is as follows:

- *Glint – a momentary flash of bright light typically received by moving receptors or from moving reflectors.*
- *Glare – a continuous source of bright light typically received by static receptors or from large reflective surfaces.*

Typical surfaces that are considered with respect to glint and glare are glass, metallic structures e.g. roofs, and solar PV panels. The orientation of a solar panel (azimuth and elevation angle) as well as its height will determine whether glint and glare effects are possible towards the assessed receptors.

The receptors that should be considered are usually ATS personnel in a control tower and pilots of aircraft within a suitable distance of an aerodrome. It is essential to conduct a glint and glare assessment when a reflective surface is to be located on or immediately adjacent to an aerodrome. In most cases, an assessment should be undertaken for a solar PV development which is being proposed within a specific distance (indicated by the aerodrome authority) from an aerodrome. For many aerodromes, 5km is the distance of choice but it could be considered out to 10km. In exceptional circumstances, assessments may be required beyond 10km.

The UK CAA and US FAA have produced guidance with respect to glint and glare however neither of them mandates a specific methodology for assessing the effects of glint and glare.

The effects of glare may mean that some solar PV developments are unacceptable, however layout modifications (such as changes to panel tilt and elevation angle) can often alleviate these concerns and overcome objections. The benefit of early consultation with the aerodrome authority cannot be understated.”
Section 4 ‘Aerodrome Operator Safety Assurance’ states:
“The aerodrome operator in conjunction with any ATS personnel should, as part of the change management process in their safety management system, consider all the potential hazards posed by solar photovoltaic developments / BESS on or in the vicinity to their aerodrome and within the aerodrome’s physical and technical safeguarded areas, in order to ensure the safety of the overall operation. The developer should provide the aerodrome with a safety survey which should include:

- *a glint and glare survey when a development is within a distance specified by the aerodrome from an Aerodrome Reference Point (ARP) (5km in most cases)*

  …

The aerodrome operator should also ensure both impact and safety assessments are undertaken to provide assurance that any on- or off-aerodrome planned development does not introduce unacceptable hazards to aircrew, ATS personnel, RFFS and aerodrome vehicle operators undertaking their tasks.

As part of the aerodrome and or ATS change management process, safety assurances should take into account any potential adverse effect to critical ATS infrastructure and equipment.

The assessment must also consider any impacts to aircraft utilising instrument flight procedures and aircraft in the visual circuit.

Developers should apply the same principals for safety assurance for unlicensed aerodromes and airfields as required by this policy that are not officially safeguarded.

The developer in conjunction with the aerodrome operator, ATS personnel, RFFS and aerodrome operations should develop adequate mitigation to mitigate any risks identified.

Should risk mitigation or agreement not be possible, the aerodrome operator should follow Local Planning Authority procedures and lodge an objection regarding the development under their statutory obligations.”

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3.2.2 US Federal Aviation Administration Guidance

In general, aviation stakeholders in the UK, as well as internationally, make use of the US FAA relevant guidance on solar energy systems as it provides a detailed methodology for assessing glint and glare.

3.2.2.1 Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports

The most comprehensive FAA guidelines available for the assessment of solar PV developments near aerodromes were initially produced in November 2010 (entitled *'Technical Guidance for Evaluating Selected Solar Technologies on Airports'*) and subsequently updated in 2013 (entitled *'Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports').*

3.2.2.2 Technical Guidance for Evaluating Selected Solar Technologies on Airports'

The 2013 edition was updated in 2018 as version 1.1 and is entitled *'Technical Guidance for Evaluating Selected Solar Technologies on Airports'*. The key changes are as follows:

> *Version 1.1 (April 2018):*
>
> *Updated Section 3.1.2, Reflectivity, to incorporate the latest information about evaluating solar glint and glare.*
> *Updated corresponding references to glare throughout the document.*
> *Clarified the relationship between solar energy and the FAA's Voluntary Airport Low Emissions (VALE) program in Section 5.3.2.*
> *Added information about the FAA's Airport Energy Efficiency Program to Section 5.3.3.*
> *Updated FAA Contact information on Appendix B (where appropriate).*

Key points from the latest FAA guidance produced in 2018 are presented in Appendix B. The full document can be accessed here.

Overall, the 2018 update offers three assessment options:

- Assessing Baseline Reflectivity Conditions
- Tests in the Field
- Geometric Analysis

3.2.2.3 Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports

A final policy entitled 'Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports' was released in 2021, which superseded the all previous guidance. The 2021 final policy has taken a step back and allowed aerodromes to safeguard as they see fit, with no longer a recommendation for any given glare model. However, where a proposed solar development is located where a risk to aviation safety is possible, geometric analysis, as per the 2013 guidance, will likely be the only option available to alleviate concerns. Aerodromes in the UK and internationally safeguard against glint and glare based on the 2018 FAA guidance.

Key points from the 2013 guidance are replicated below:

> *"…the FAA has determined that glint and glare from solar energy systems could result in an ocular impact to pilots and/or air traffic control (ATC) facilities and compromise the safety of the air transportation system. While the FAA supports solar energy systems on airports, the FAA seeks to ensure safety by eliminating the potential for ocular impact to pilots and/or air traffic control facilities due to glare from such projects."*
>
> ***Standard for Measuring Ocular Impact***
>
> *"FAA adopts the Solar Glare Hazard Analysis Plot[7] as the standard for measuring the ocular impact of any proposed solar energy system on a federally-obligated airport. To obtain FAA approval to revise an airport layout plan to depict a solar installation and/or a "no objection" to*

[7] Plot provided in Section 4.4.1.

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a Notice of Proposed Construction Form 7460-1, the airport sponsor will be required to demonstrate that the proposed solar energy system meets the following standards:

1. No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and

2. No potential for glare or "low potential for after-image" (shown in green in hazard plot) along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath.

Ocular impact must be analysed over the entire calendar year in one (1) minute intervals from when the sun rises above the horizon until the sun sets below the horizon."

Tool to Assess Ocular Impact

"In cooperation with the Department of Energy (DOE), the FAA is making available free-of-charge the Solar Glare Hazard Analysis Tool (SGHAT). The SGHAT was designed to determine whether a proposed solar energy project would result in the potential for ocular impact as depicted on the Solar Glare Hazard Analysis Plot shown above."

Required Use of SGHAT

"As of the date of publication of this interim policy, the FAA requires the use of the SGHAT to demonstrate compliance with the standards for measuring ocular impact stated above for any proposed solar energy system located on a federally-obligated airport. The SGHAT is a validated tool specifically designed to measure glare according to the Solar Glare Hazard Analysis Plot. All sponsors of federally obligated airports who propose to install or to permit others to install solar energy systems on the airport must attach the SGHAT report, outlining solar panel glare and ocular impact, for each point of measurement to the Notice of Proposed Construction Form 7460-1. The FAA will consider the use of alternative tools or methods on a case-by-case basis. However, the FAA must approve the use of an alternative tool or method prior to an airport sponsor seeking approval for any proposed on-airport solar energy system. The alternative tool or method must evaluate ocular impact in accordance with the Solar Glare Hazard Analysis Plot."

The Glint and Glare evaluation will be undertaken using ForgeSolar software. ForgeSolar succeeds the Solar Glare Hazard Analysis Tool (SGHAT), whose use was required by the FAA to demonstrate compliance with the standards for measuring ocular impact for any proposed solar energy systems at airports. ForgeSolar is the leading software specialist for modelling glare impacts and the software is used extensively across the UK for assessing impacts toward airports. Further details are provided in Section 4.1 of this report.

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Section 4.0: Methodology

A desk-based assessment is undertaken to assess glint and glare that may be experienced by light-sensitive receptors within the vicinity of the proposed solar PV development.

4.1 Solar Reflection Model

A computational modelling tool was used, where appropriate/required, to model and assess solar reflectivity of the proposed development in relation to specified receptors, in line with FAA guidance.

The tool employs an interactive Google map where the site location, proposed solar energy system and receptor paths/locations can be specified. Latitude, longitude, and elevation are automatically recorded through the Google interface, providing necessary information for sun position and vector calculations.

PV systems are represented by contiguous planar polygon footprints and a set of customisable parameters. Each footprint comprises three or more vertices, defined by a latitude, longitude, elevation, and height. Each distinct PV installation or array is modelled with its own PV array footprint. The PV panel tilt, orientation, and height are considered to be the same across the entire array. This is considered acceptable due to the distance of the sun from the proposed development and the relatively small differences in location of the sun over the proposed development.

The solar reflectance of the PV modules is specified based on the module surface material. The modelling tool has five general module material reflectance profiles which were developed by analysing different PV module samples. The following options are available:

- Smooth glass without ARC
- Smooth glass with ARC
- Light textured glass without ARC
- Light textured glass with ARC
- Deeply textured glass

During analysis, sunlight is reflected over each PV array on a minute-by-minute basis according to the specified module tilt and orientation or axis tracking parameters, if the system is not fixed-mount. The system then checks whether the resulting solar reflections intersect (impact) the specified receptors, thus predicting glint and glare occurrence.

4.2 Receptor Identification

In general, light-sensitive receptors with view of a solar PV development have potential to experience solar reflection. While no technical distance limits/thresholds are reported within which solar reflections are possible for such receptors, the potential or significance of a reflection decreases with distance due to an observer's decreasing field of vision capability with increasing distance, as well as possible obstructions such as shielding caused by terrain and vegetation.

The typical visual circuit comprises five main legs, which are:

- Departure. Aircraft starts its ascent on a straight flight path parallel and in the direction of the landing runway.
- Crosswind leg. Aircraft turns and travels at right angles to runway, continuing its ascent to level out at the maximum circuit altitude.
- Downwind leg. Aircraft travels at the maximum circuit altitude in a long path in the opposite direction of the runway.
- Base leg. Aircraft turns and starts its descent at right angles to the final approach leg and the extended runway centreline;
- Final approach. Aircraft continues descent on a straight flight path towards the runway.

For the purpose of this assessment, the following good practice considerations will be applied, incorporating relevant guidance as laid out in Section 3.0, where applicable.

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Aviation	**Aerodromes** In accordance with CAA CAST guidance, aerodromes located: ▪ Within less than 5 km of proposed development, will be assessed for glint and glare. ▪ Within 5-10 km away from the proposed development will be identified but not necessarily modelled. Assessment may be requested by relevant aerodrome safeguarding authority during consultation. ▪ Beyond 10 km radius from the proposed development are not considered. In accordance with US FAA guidance, the recommended modelling assessment methodology is: ▪ Additional height above ground level will be considered to represent the viewing height of an air controller within the ATCT (ATCT height). ▪ 2-mile approach path thresholds towards runway(s) will be assessed, with starting points taken at 15.2 m above runway threshold at a 3-degree descent path (unless otherwise stated). ▪ Reference aircraft location receptor points will be taken at no more than ¼ miles intervals, with a minimum of 9 points, over the 2-mile approach paths identified. ▪ A pilot azimuthal field-of-view (FOV) of 100° will be applied (50° view angle either side of direction of travel). According to the FAA, glare that appears beyond this FOV range is mitigated. ▪ A pilot vertical FOV of 30° will be applied. Anything appearing beyond this FOV is not visible to the pilot and is acceptable to FAA. The in-built 2-mile flight approach path tool within ForgeSolar enables field of view of pilots to be considered in the assessment. **Visual Circuits** ▪ Visual circuits will be assessed as 40 location receptor points at evenly spaced intervals along the designated circuit provided by the relevant Airport Safeguarding Authority. The ascent and descent paths are flown at 4.5-degrees for runway 02 and 3.5-degrees for runway 20. The helicopter training circuit will be modelled at a 5-degree ascent and decent path. 1. Left-hand runway circuits from runways 20 grass and asphalt: Receptor points at even intervals in the visual circuit at 1100feet and 1NM downwind leg. After take-off, climb straight ahead, then left turn cross wind for 1NM before turning downwind. The circuit height is 1100ft AGL downwind, parallel to the active runway. This is followed by a turn onto the base leg ready for the final turn on to the final approach. 2. Left-hand runway circuits from runways 02 grass and asphalt: Receptor points at even intervals in the visual circuit at 1100feet and 1NM downwind leg. After take-off, climb straight ahead. When crossing the railway line turn right 10 degrees, then right turn cross wind for 1NM before turning downwind. The circuit height is 1100ft AGL downwind, parallel to the active runway. This is followed by a turn onto the base leg ready for the final turn on to the final approach. 3. Right-hand helicopter training circuit: Climb on a track parallel to the departure lane from the main runway. When crossing the railway line, turn right 10 degrees. Continue to the coast and turn north-east for the downwind leg. Continue climb to 800 FT QNH, to be level by the football training ground. After crossing the A27, descend to 600 FT QNH to be level before turning east. Upon reaching the River Adur, turn south towards the aerodrome and make the approach to HTA 'W'. 4. Left-hand helicopter training circuit. Climb to the north-east to 600 FT QNH. On turning south on the downwind leg, climb to 800 FT QNH, to be level before crossing the A27. When passing over the football ground, descend to 600 FT

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	QNH and continue to the coast before turning left toward the aerodrome and make the approach to HTA 'W'.

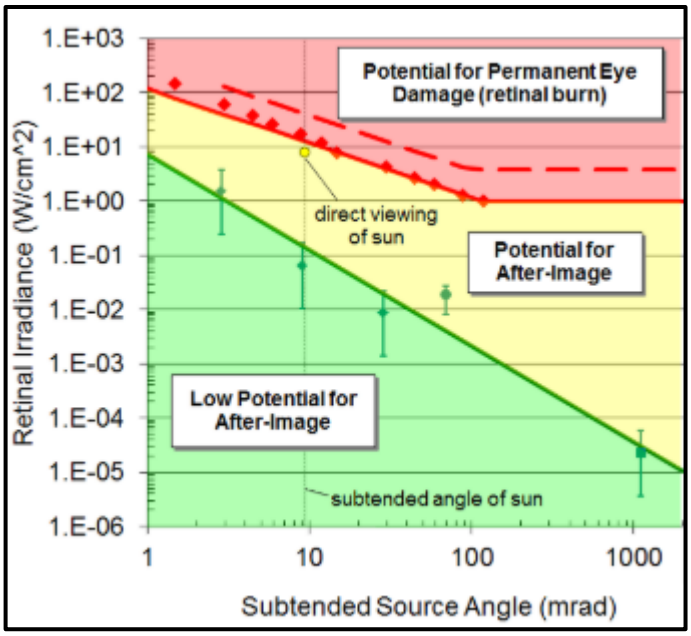
4.3 Magnitude of Impact

4.3.1 Ocular Impact

Ocular impact significance depends on the line of sight between the reflector (solar PV panels) and the receptor, the location of the receptor relative to the reflector and thus the solar reflection, the time of the day, they path between the sun and the reflective surface, and the reflection exposure period (e.g. momentary exposure is less significant that prolonged exposure).

As such, ocular impact can be classified into three levels based on the retinal irradiance and subtended source angle: low potential for after-image (**green**), potential for after-image (**yellow**), and potential for permanent eye damage (**red**). These categories are illustrated in the Ocular Hazard plot[8] shown in Figure 4.1 (NOTE: this is a universal Ocular Hazard plot and does not represent potential glare conditions that may be experienced at the proposed development.).

Figure 4.1: Ocular Hazard Plot



The subtended source angle represents the size of glare observed by receptor, while the retinal irradiance is the quantity of energy impacting the retina of the observer. As it can be seen from Figure 4.1, wide subtended source angles can cause retinal irritation/damage even at low retinal irradiance.

4.3.2 Glint & Glare Impact Significance

4.3.2.1 Aviation

Air Traffic Control Towers (ATCT)

The FAA 2013 and 2018 guidance (which has now been superseded) stated:

Acceptable	***'No potential for glint and glare'*** towards ATCT should be produced by a proposed solar PV development.
Unacceptable	Any glare of any duration/frequency predicted towards ATCT from proposed solar PV development.

In accordance with industry guidance, it is recommended that any predicted solar reflection is assessed pragmatically. Therefore, the following mitigating factors will also be considered when determining whether a solar reflection is significant:

[8] Sliney, D.H. and B.C. Freasier, 1973, Evaluation of Optical Radiation Hazards, Applied Optics, 12(1), p. 1-24.

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1. The relative position and visibility of the reflecting panels relative to the aerodrome's key operational areas – glare originating near sensitive areas such as the runway threshold will have a higher impact upon the ATC Tower personnel than that away from other areas;
2. Separation distance from panels to ATCT personnel – at longer distances, the proportion of an observer's field of vision that is taken up by the reflecting area is reduced;
3. The predicted intensity of the solar reflection;
4. Solar reflection duration per day;
5. Number of days a solar reflection is geometrically possible per year; and
6. The time of day when a solar reflection is geometrically possible.

Industry guidance states:

No or Insignificant Impact	Solar reflection is not geometrically possible or will not be visible from the assessed receptor. Mitigation not required.
Low	Glare has a maximum intensity of "low potential for temporary after-image" (green glare) with sufficient mitigating factors. Mitigation not recommended.
Moderate	Glare has an intensity of "low potential for temporary after-image" (green glare) or "potential for temporary after-image" (yellow glare) with limited mitigating factors. Mitigation recommended.
High	Glare has an intensity of "low potential for temporary after-image" (green glare) or "potential for temporary after-image" (yellow glare) with no mitigating factors. Mitigation required.

Approaching Aircrafts

Whilst the new CAA CAST guidance has provided additional information on the receptors that may require assessment within a Glint and Glare Assessment, it does not provide clarity with regards to how to interpret glint and glare assessment results. The guidance produced by CAST also does not provide a summary of what different impacts mean and recommends that the aerodrome authority review their own risk assessments and make a judgement as to what the results will mean within their own aerodrome.

The FAA 2013 and 2018 guidance (which has now been revoked) stated:

Acceptable	***'No potential for glare'*** or ***'low potential for after-image'*** along the final approach path for any existing or future landing thresholds (as defined in Section 3.2.2).
Unacceptable	Glare with '***potential for temporary after-image***' predicted towards the final approach path.

In accordance with industry guidance, it is recommended that any predicted solar reflection is assessed pragmatically. Therefore, the following mitigating factors will also be considered when determining whether a solar reflection is significant:

1. The relative position and visibility of the reflecting panels relative to final approach path and whether the glare is within the field of view of pilots;
2. Solar reflection duration per day;
3. Number of days a solar reflection is geometrically possible per year;
4. The time of day when a solar reflection is geometrically possible.
5. The length of the section of the final approach that is potentially affected by glare;
6. Reflectors in the existing environment;
7. The extent to which impacts coincide with effects of direct sunlight; and

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8. Likely aerodrome traffic volumes, operational procedures or restrictions specific to the aerodrome, where applicable/provided.

Industry guidance states:

No or Insignificant Impact	Solar reflection is not geometrically possible or will not be visible from the assessed receptor.
Low	Under the following scenarios, low impact may be designated: • Solar reflections originate outside a pilot's main field of view. • Glare has a "low potential for temporary after-image" (green glare). • Glare has a "potential for temporary after-image" (yellow glare) with sufficient mitigating factors. • Aerodrome has confirmed the level of glare is acceptable. Mitigation is not considered necessary.
Moderate	Glare has a "potential for temporary after-image" (yellow glare) and there are insufficient mitigating factors. Mitigation may be required at regulator's discretion.
High	Glare has a "potential for permanent eye damage" (red glare). Mitigation recommended if the Proposed Development is to proceed.

Visual Circuits & Local Flight Manoeuvring Areas Assessment

Guidance for impact categorisation is not as standardised for aircraft in Visual Circuits and Local Flight Manoeuvring Areas as it is for flight approach paths or ATCTs.

As a conservative approach the glare shall be assessed using the same criteria as an approaching aircraft, including review of mitigating factors:

No or Insignificant Impact	Solar reflection is not geometrically possible or will not be visible from the assessed receptor.
Low	Under the following scenarios, low impact may be designated: • Solar reflections originate outside a pilot's main field of view. • Glare has a "low potential for temporary after-image" (green glare). • Glare has a "potential for temporary after-image" (yellow glare) with sufficient mitigating factors. • Aerodrome has confirmed the level of glare is acceptable. Mitigation is not considered necessary.
Moderate	Glare has a "potential for temporary after-image" (yellow glare) and there are insufficient mitigating factors. Mitigation may be required at regulator's discretion.
High	Glare has a "potential for permanent eye damage" (red glare). Mitigation recommended if the Proposed Development is to proceed.

4.4 Time Zone / Datum

The UK uses British Summer Time (BST, UTC +01:00) in the summer and Greenwich Mean Time (GMT, UTC +0) in the winter. For the purpose of this report all time references are in GMT.

All locations are given in Eastings and Northings using the UK National Grid Reference system, unless otherwise specified.

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4.5 Assumptions, Limitations & Fixed Model Variables

Provided in Appendix C is a list of assumptions, limitations and fixed variables of the model and assessment methodology.

4.6 Modelling Obstructions

The obstruction component in ForgeSolar simulates obstacles and blocking geometries that may mitigate glare. For example, obstructions can represent tree cover, buildings, and geographic elements.

Obstructions are modelled as multi-line paths comprising 2 to 10 vertices. Obstructions may block PV glare reflections from reaching receptors. They may also block incoming sunlight from reaching the reflective surface. Obstruction segments are modelled as parallelograms with vertical sides that extend upward from the ground. The top "corners" are described by the vertex point elevations and the upper edge height. Obstructions are assumed to be opaque i.e. incoming sunlight and emanating glare reflections are completely mitigated if they intersect the obstruction face.

4.7 Elevation Data

Elevation data for the modelled flight paths and ATCT were obtained using DEFRA Survey[9] LiDAR data database. Digital Terrain Model and Digital Surface Model data was downloaded from the most recent survey. ForgeSolar employs an interactive Google map such that latitude, longitude, and ground elevation of PV geometry and receptors are automatically queried from Google, providing necessary information for sun position and vector calculations.

[9] https://environment.data.gov.uk/survey

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Section 5.0: Receptor Screening & Modelling Considerations

5.1 Aviation Infrastructure

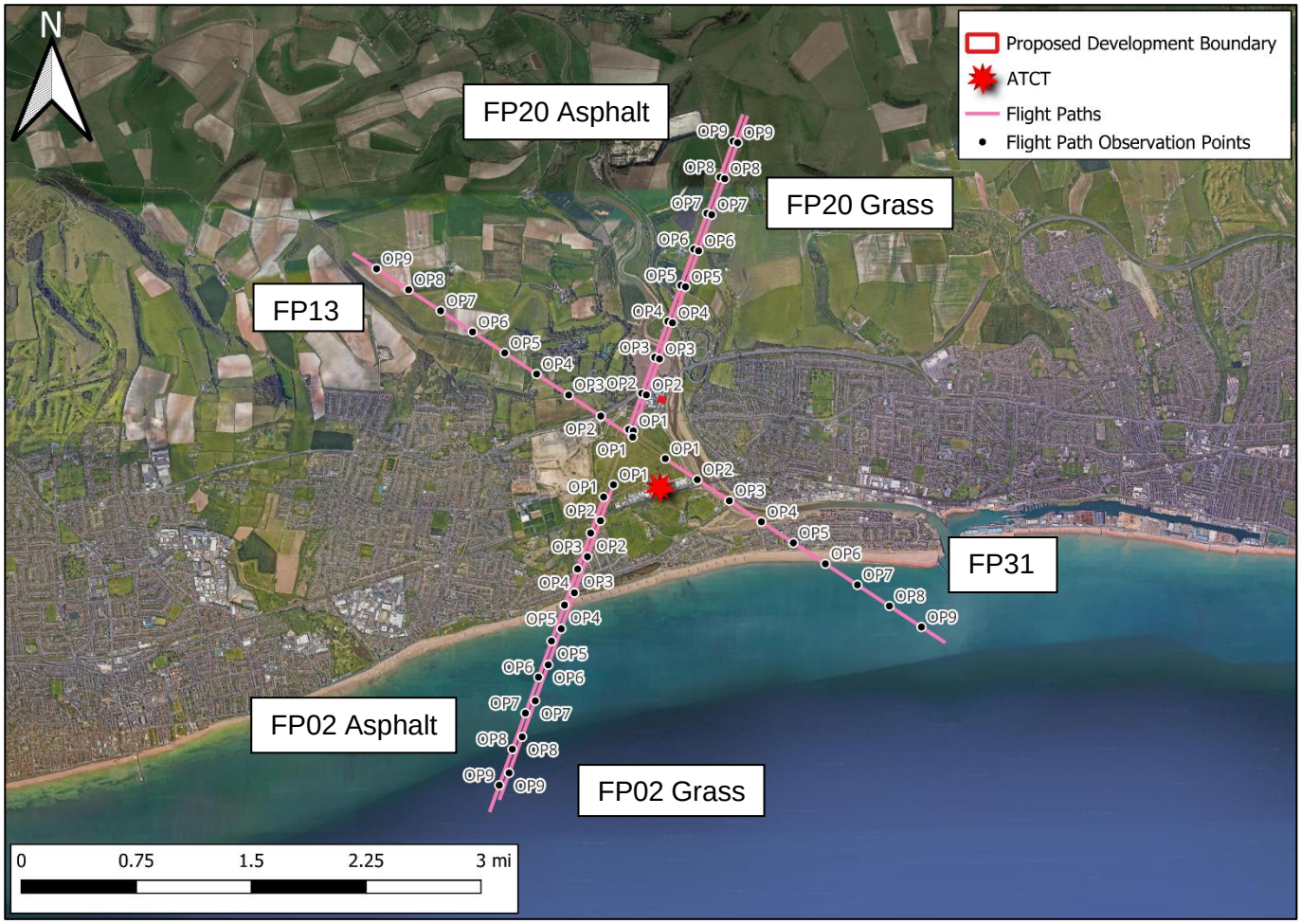
5.1.1 Brighton City Airport Flight Approach Paths and ATCT

Brighton City Airport is located approximately 500m due south from the Proposed Development. The airport has four runways and eight approach paths (02/20 asphalt, 02/20 grass, 13/31 and 24/06). After correspondence with Brighton City Airport, modelling for runway 24/06 is not required due to low use.

The airport's ATCT is located to the north of the runways, and it has a height of approximately 15.3 m.

The six modelled approach paths and the ATCT are shown below in Figure 5.1.

Figure 5.1: Brighton City Airport Flight Paths and ATCT



Imagery © 2024 Google

The approach flight paths at Brighton City Airport were modelled using observation points (OPs) at 0.25-mile intervals. The flight path height at each OP follows the below altitude profiles:

5.1.1.1 FP 02: 4.5-degree ascent/descent path

Observation Point	Distance from Runway Threshold	Altitude Above Ground (m)
OP1	Threshold – point closest to ground/runway (0 miles)	15.2
OP2	¼ miles	46.9
OP3	½ miles	78.5
OP4	¾ miles	110.2
OP5	1 miles	141.9
OP6	1 ¼ miles	173.5

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Observation Point	Distance from Runway Threshold	Altitude Above Ground (m)
OP7	1 ½ miles	205.2
OP8	1 ¾ miles	236.9
OP9	2 miles	268.5

5.1.1.2 FP 20: 3.5-degree ascent/descent path

Observation Point	Distance from Runway Threshold	Altitude Above Ground (m)
OP1	Threshold – point closest to ground/runway (0 miles)	15.2
OP2	¼ miles	39.8
OP3	½ miles	64.4
OP4	¾ miles	89.0
OP5	1 miles	113.6
OP6	1 ¼ miles	138.2
OP7	1 ½ miles	162.8
OP8	1 ¾ miles	187.5
OP9	2 miles	212.1

5.1.1.3 FP 02/20 grass and FP 13/31: 3-degree ascent/descent path

Observation Point	Distance from Runway Threshold	Altitude Above Ground (m)
OP1	Threshold – point closest to ground/runway (0 miles)	15.2
OP2	¼ miles	36.3
OP3	½ miles	57.4
OP4	¾ miles	78.5
OP5	1 miles	99.5
OP6	1 ¼ miles	120.6
OP7	1 ½ miles	141.7
OP8	1 ¾ miles	162.8
OP9	2 miles	183.9

5.1.2 Brighton City Airport Visual Circuits

In addition to the approach flight paths and ATCT, Brighton City Airport requests that visual circuits are assessed. A visual circuit path involves an aircraft taking off from the runway at an airport, turning and flying a circuit around the airport before landing at the runway again.

Following correspondence with Brighton City Airport, the following Glint and Glare scope has been agreed:

- Runway circuits (02/20 asphalt and grass):
  - Left-hand circuits from each runway
  - Height 1,100ft (335.3m) above the airfield
  - A descent angle of 3.5 degrees from runway 20, and 4.5 degrees from runway 02
- Helicopter training circuit:
  - Circuit to the west of runway 02/20
  - Heights 600ft (182.9m) above the airfield, ascending to 800ft (243.8) passing over the A27
  - Circuit shape following extract from UK AIP - Shoreham[10]

Figures 5.2-5.6 show the circuits with OPs spaced at equal intervals along the circuit path.

The OP heights during the ascent/descent stage of the circuit, based on a threshold crossing height of 15.2 m, are given below.

[10] Aedrome/Heliport EGKA (ead-it.com)

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5.1.2.1 Asphalt Circuit 02 right turn, 20 left turn

Observation Point	Distance from Runway Threshold (NM)	Altitude Above Runway Level (m)	Journey Leg
OP1	0.0	15.2	Departure
OP2	0.275	46.4	Departure
OP3	0.55	77.5	Departure
OP4	0.825	108.7	Departure
OP5	1.1	139.8	Departure
OP6	1.375	171.0	Departure
OP7	1.65	202.1	Departure
OP8	1.925	233.3	Departure
OP9	2.2	264.4	Departure
OP10	2.475	295.6	Crosswind leg
OP11	2.75	326.7	Crosswind leg
OP12	3.025	335.3	Crosswind leg
OP13	3.3	335.3	Downwind leg
OP14	3.575	335.3	Downwind leg
OP15	3.85	335.3	Downwind leg
OP16	4.125	335.3	Downwind leg
OP17	4.4	335.3	Downwind leg
OP18	4.675	335.3	Downwind leg
OP19	4.95	335.3	Downwind leg
OP20	5.225	335.3	Downwind leg
OP21	5.5	335.3	Downwind leg
OP22	5.775	335.3	Downwind leg
OP23	6.05	335.3	Downwind leg
OP24	6.325	335.3	Downwind leg
OP25	6.6	335.3	Downwind leg
OP26	6.875	335.3	Downwind leg
OP27	7.15	335.3	Downwind leg
OP28	7.425	335.3	Downwind leg
OP29	7.7	335.3	Downwind leg
OP30	7.975	335.3	Base leg
OP31	8.25	335.3	Base leg
OP32	8.525	335.3	Base leg
OP33	8.8	295.8	Final approach
OP34	9.075	255.7	Final approach
OP35	9.35	215.6	Final approach
OP36	9.625	175.5	Final approach
OP37	9.9	135.4	Final approach
OP38	10.175	95.4	Final approach
OP39	10.45	55.3	Final approach
OP40	10.725	15.2	Final approach

As shown in Figure 5.2, points ordered OP1 to OP26 detail the departure from runway 20, with aviation undertaking following a circuit of left turns to the final approach to runway 02.

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Figure 5.2: Runway 02/20 Visual Circuit 20 Left Turn, 02 Right Turn



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5.1.2.2 Grass Circuit 02 right turn, 20 left turn

Observation Point	Distance from Runway Threshold (NM)	Altitude Above Runway Level (m)	Journey Leg
OP1	0	15.2	Departure
OP2	0.2775	46.6	Departure
OP3	0.555	78.1	Departure
OP4	0.8325	109.5	Departure
OP5	1.11	140.9	Departure
OP6	1.3875	172.4	Departure
OP7	1.665	203.8	Departure
OP8	1.9425	235.2	Departure
OP9	2.22	266.7	Departure
OP10	2.4975	298.1	Crosswind leg
OP11	2.775	329.5	Crosswind leg
OP12	3.0525	335.3	Crosswind leg
OP13	3.33	335.3	Downwind leg
OP14	3.6075	335.3	Downwind leg
OP15	3.885	335.3	Downwind leg
OP16	4.1625	335.3	Downwind leg
OP17	4.44	335.3	Downwind leg
OP18	4.7175	335.3	Downwind leg
OP19	4.995	335.3	Downwind leg
OP20	5.2725	335.3	Downwind leg
OP21	5.55	335.3	Downwind leg
OP22	5.8275	335.3	Downwind leg
OP23	6.105	335.3	Downwind leg

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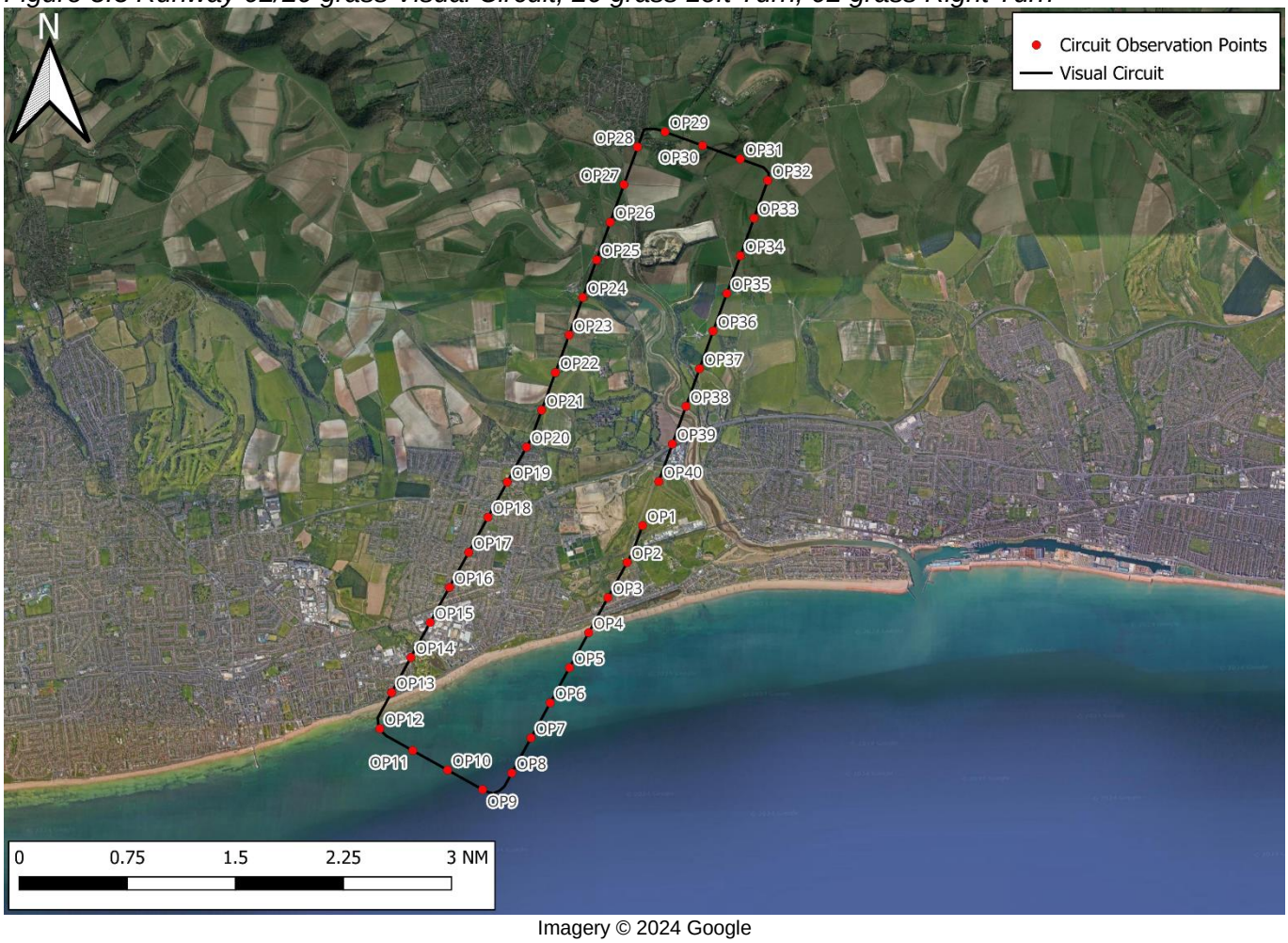
Observation Point	Distance from Runway Threshold (NM)	Altitude Above Runway Level (m)	Journey Leg
OP24	6.3825	335.3	Downwind leg
OP25	6.66	335.3	Downwind leg
OP26	6.9375	335.3	Downwind leg
OP27	7.215	335.3	Downwind leg
OP28	7.4925	335.3	Downwind leg
OP29	7.77	335.3	Downwind leg
OP30	8.0475	335.3	Base leg
OP31	8.325	335.3	Base leg
OP32	8.6025	335.3	Base leg
OP33	8.88	298.3	Final approach
OP34	9.1575	257.9	Final approach
OP35	9.435	217.4	Final approach
OP36	9.7125	177.0	Final approach
OP37	9.99	136.5	Final approach
OP38	10.2675	96.1	Final approach
OP39	10.545	55.6	Final approach
OP40	10.8225	15.2	Final approach

As shown in Figure 5.3, points ordered OP1 to OP40 detail the departure from runway 20 grass, with aviation undertaking following a circuit of left turns to the final approach to runway 02 grass.

Figure 5.3 Runway 02/20 grass Visual Circuit, 20 grass Left Turn, 02 grass Right Turn



Imagery © 2024 Google

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5.1.2.3 Asphalt Circuit 02 left turn, 20 right turn

Observation Point	Distance from Runway Threshold (NM)	Altitude Above Runway Level (m)	Journey Leg
OP1	0	15.2	Departure
OP2	0.283	56.4	Departure
OP3	0.566	97.7	Departure
OP4	0.849	138.9	Departure
OP5	1.132	180.2	Departure
OP6	1.415	221.4	Departure
OP7	1.698	262.7	Departure
OP8	1.981	303.9	Departure
OP9	2.264	335.3	Crosswind leg
OP10	2.547	335.3	Crosswind leg
OP11	2.83	335.3	Crosswind leg
OP12	3.113	335.3	Downwind leg
OP13	3.396	335.3	Downwind leg
OP14	3.679	335.3	Downwind leg
OP15	3.962	335.3	Downwind leg
OP16	4.245	335.3	Downwind leg
OP17	4.528	335.3	Downwind leg
OP18	4.811	335.3	Downwind leg
OP19	5.094	335.3	Downwind leg
OP20	5.377	335.3	Downwind leg
OP21	5.66	335.3	Downwind leg
OP22	5.943	335.3	Downwind leg
OP23	6.226	335.3	Downwind leg
OP24	6.509	335.3	Downwind leg
OP25	6.792	335.3	Downwind leg
OP26	7.075	335.3	Downwind leg
OP27	7.358	335.3	Downwind leg
OP28	7.641	335.3	Downwind leg
OP29	7.924	335.3	Base leg
OP30	8.207	335.3	Base leg
OP31	8.49	303.7	Base leg
OP32	8.773	271.7	Final approach
OP33	9.056	239.6	Final approach
OP34	9.339	207.5	Final approach
OP35	9.622	175.5	Final approach
OP36	9.905	143.4	Final approach
OP37	10.188	111.4	Final approach
OP38	10.471	79.3	Final approach
OP39	10.754	47.3	Final approach
OP40	11.037	15.2	Final approach

As shown in Figure 5.4, points ordered OP1 to OP40 detail the departure from runway 02, with aviation undertaking following a circuit of left turns to the final approach to runway 20.

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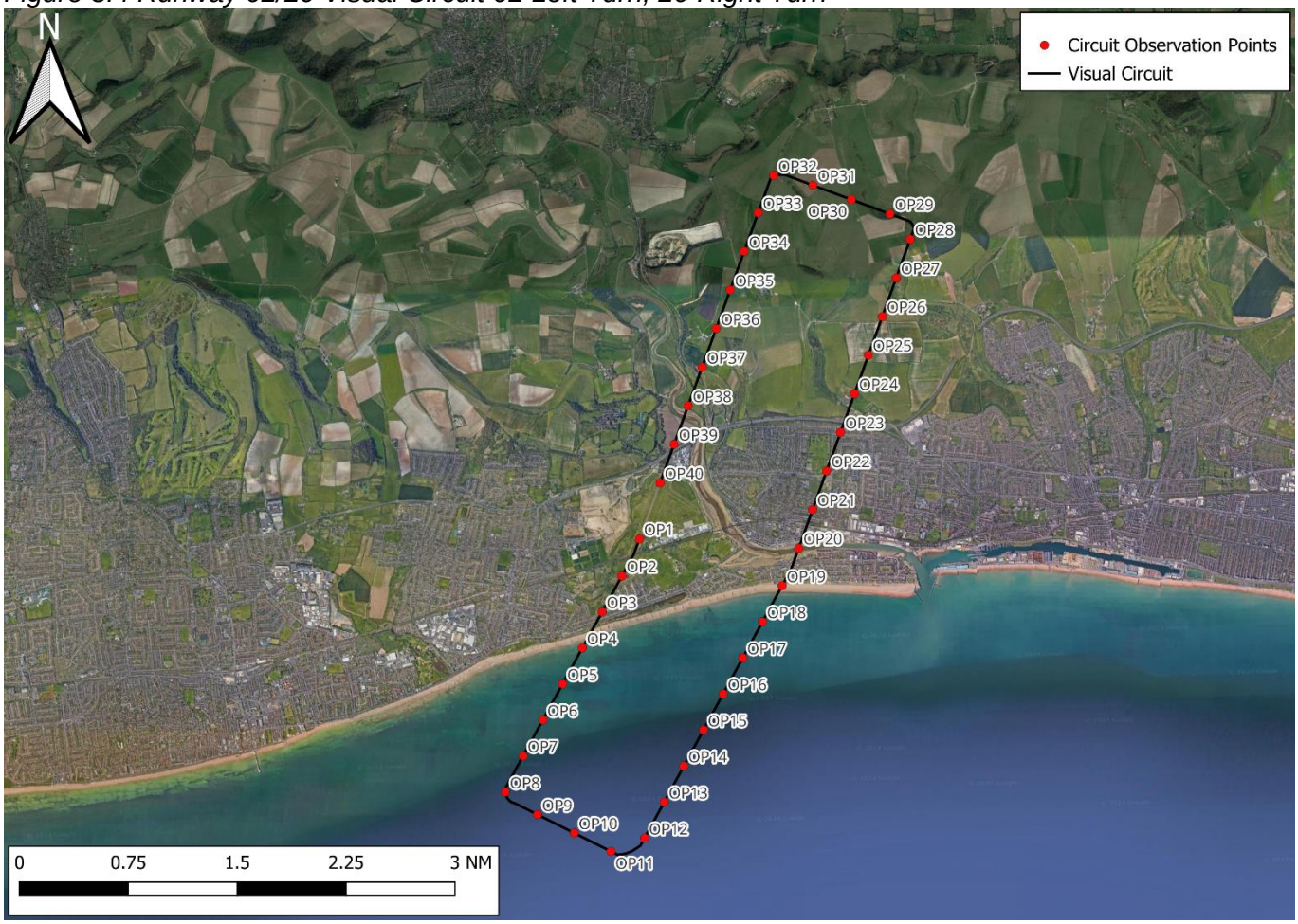
Figure 5.4 Runway 02/20 Visual Circuit 02 Left Turn, 20 Right Turn



Imagery © 2024 Google

5.1.2.4 Grass Circuit 02 left turn, 20 right turn

Observation Point	Distance from Runway Threshold (NM)	Altitude Above Runway Level (m)	Journey Leg
OP1	0	15.2	Departure
OP2	0.285	56.7	Departure
OP3	0.57	98.3	Departure
OP4	0.855	139.8	Departure
OP5	1.14	181.4	Departure
OP6	1.425	222.9	Departure
OP7	1.71	264.4	Departure
OP8	1.995	306.0	Departure
OP9	2.28	335.3	Crosswind leg
OP10	2.565	335.3	Crosswind leg
OP11	2.85	335.3	Crosswind leg
OP12	3.135	335.3	Downwind leg
OP13	3.42	335.3	Downwind leg
OP14	3.705	335.3	Downwind leg
OP15	3.99	335.3	Downwind leg
OP16	4.275	335.3	Downwind leg
OP17	4.56	335.3	Downwind leg
OP18	4.845	335.3	Downwind leg
OP19	5.13	335.3	Downwind leg
OP20	5.415	335.3	Downwind leg
OP21	5.7	335.3	Downwind leg
OP22	5.985	335.3	Downwind leg
OP23	6.27	335.3	Downwind leg

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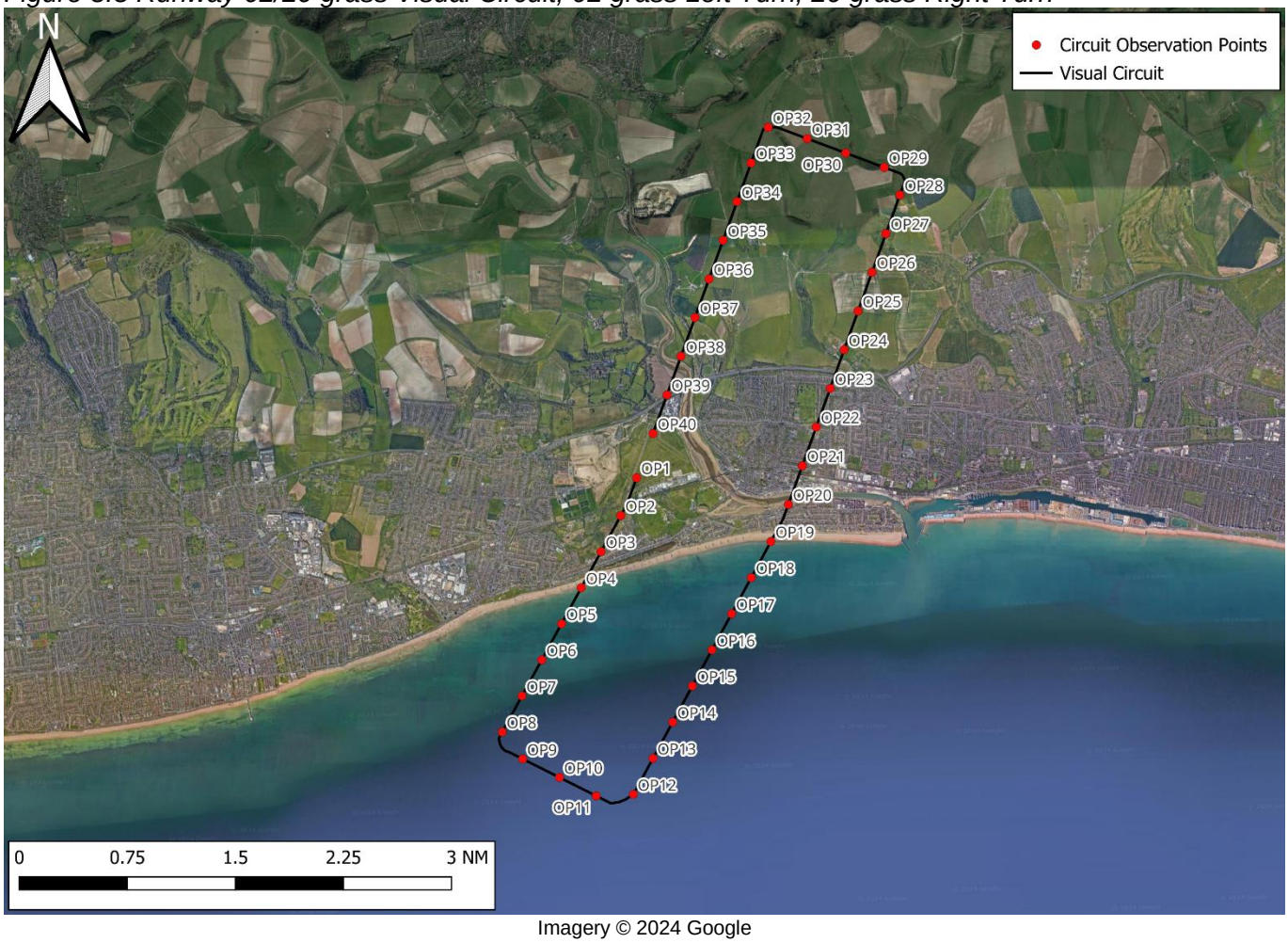
Observation Point	Distance from Runway Threshold (NM)	Altitude Above Runway Level (m)	Journey Leg
OP24	6.555	335.3	Downwind leg
OP25	6.84	335.3	Downwind leg
OP26	7.125	335.3	Downwind leg
OP27	7.41	335.3	Downwind leg
OP28	7.695	335.3	Downwind leg
OP29	7.98	335.3	Base leg
OP30	8.265	335.3	Base leg
OP31	8.55	305.7	Base leg
OP32	8.835	273.5	Final approach
OP33	9.12	241.2	Final approach
OP34	9.405	208.9	Final approach
OP35	9.69	176.6	Final approach
OP36	9.975	144.3	Final approach
OP37	10.26	112.0	Final approach
OP38	10.545	79.8	Final approach
OP39	10.83	47.5	Final approach
OP40	11.115	15.2	Final approach

As shown in Figure 5.5, points ordered OP1 to OP40 detail the departure from runway 02 grass, with aviation undertaking following a circuit of left turns to the final approach to runway 20 grass.

Figure 5.5 Runway 02/20 grass Visual Circuit, 02 grass Left Turn, 20 grass Right Turn



Imagery © 2024 Google

5.1.2.5 Helicopter Training Circuit

Observation Point	Distance from Runway Threshold (NM)	Altitude Above Runway Level (m)
OP1	0	15.2
OP2	0.109	32.9
OP3	0.218	50.5
OP4	0.327	68.2
OP5	0.436	85.8
OP6	0.545	103.5
OP7	0.654	121.2
OP8	0.763	138.8
OP9	0.872	156.5
OP10	0.981	174.2
OP11	1.09	182.9
OP12	1.199	182.9
OP13	1.308	182.9
OP14	1.417	182.9
OP15	1.526	182.9
OP16	1.635	182.9
OP17	1.744	182.9
OP18	1.853	191.8
OP19	1.962	209.5
OP20	2.071	227.1
OP21	2.18	243.8
OP22	2.289	243.8
OP23	2.398	243.8
OP24	2.507	243.8
OP25	2.616	227.1
OP26	2.725	209.5
OP27	2.834	191.8
OP28	2.943	182.9
OP29	3.052	182.9
OP30	3.161	182.9
OP31	3.27	174.2
OP32	3.379	156.5
OP33	3.488	138.8
OP34	3.597	121.2
OP35	3.706	103.5
OP36	3.815	85.8
OP37	3.924	68.2
OP38	4.033	50.5
OP39	4.142	32.9
OP40	4.251	15.2

As shown in Figure 5.6, points ordered OP1 to OP40 detail the departure from runway 20, with aviation undertaking following the below circuit to the final approach to runway 02.

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Figure 5.6 Helicopter Training Circuit



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5.2 Modelled Obstructions

There is an approximate 0.5m tall parapet on the roof edge of the Proposed Development building. As such, this has been modelled as an obstruction within the model, as shown in Figure 5.7.

Figure 5.7 Modelled Parapet Obstruction



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The modelled height of the obstruction is 10.525m, based on information provided by Ricardo.

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Section 6.0: Modelling Results & Interpretation

6.1 Aviation – Brighton City Airport

Receptor	Results	Impact
ATCT	***No glare predicted***	**No Impact**
FP02 Asphalt	***No glare predicted***	**No Impact**
FP20 Asphalt	Glare with ***'low potential for temporary after-image'*** is predicted at OP 2. With reference to the impact significance guidance (Section 4.3.2.1), glare predicted toward pilots on final approach with a *'low potential for after-image'* (green glare) is a "low" impact.	**Low Impact**
FP02 Grass	***No glare predicted***	**No Impact**
FP20 Grass	Glare with ***'low potential for temporary after-image'*** is predicted at OP 2. With reference to the impact significance guidance (Section 4.3.2.1), glare predicted toward pilots on final approach with a *'low potential for after-image'* (green glare) is a "low" impact.	**Low Impact**
FP13	Glare with ***'low potential for temporary after-image'*** is predicted at OPs 2-7. With reference to the impact significance guidance (Section 4.3.2.1), glare predicted toward pilots on final approach with a *'low potential for after-image'* (green glare) is a "low" impact.	**Low Impact**
FP31	***No glare predicted***	**No Impact**
Asphalt Circuit 02 Right Turn, 20 Left Turn	Glare with ***'low potential for temporary after-image'*** is predicted at OPs 17-22 and OP 39. With reference to the impact significance guidance (Section 4.3.2.1), glare predicted toward pilots in a visual circuit with a 'low potential for after-image' (green glare) is a "low" impact.	**Low Impact**
Grass Circuit 02 Right Turn, 20 Left Turn	Glare with ***'low potential for temporary after-image'*** is predicted at OPs 17-22. With reference to the impact significance guidance (Section 4.3.2.1), glare predicted toward pilots in a visual circuit with a 'low potential for after-image' (green glare) is a "low" impact.	**Low Impact**
Asphalt Circuit 02 Left Turn, 20 Right Turn	Glare with ***'low potential for temporary after-image'*** is predicted at OPs 21-31. With reference to the impact significance guidance (Section 4.3.2.1), glare predicted toward pilots in a visual circuit with a 'low potential for after-image' (green glare) is a "low" impact.	**Low Impact**
Grass Circuit 02 Left Turn, 20 Right Turn	Glare with ***'low potential for temporary after-image'*** is predicted at OPs 21-31. With reference to the impact significance guidance (Section 4.3.2.1), glare predicted toward pilots in a visual circuit with a 'low potential for after-image' (green glare) is a "low" impact.	**Low Impact**
Helicopter Training Circuit	Glare with ***'low potential for temporary after-image'*** is predicted at OPs 18-25 and OPs 38-39.	**Low Impact**

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Receptor	Results	Impact
	With reference to the impact significance guidance (Section 4.3.2.1), predicted glare toward pilots in a visual circuit with a ‘low potential for after-image’ (green glare) is a “low” impact.	

Detailed results can be provided on request.

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Section 7.0: Conclusions

7.1 Assessment Findings Summary

Technical glare modelling was undertaken for the potential impact of the Proposed Development on aviation receptors at Brighton City Airport.

The modelling predicts no glare toward the airport's Air Traffic Control Tower and pilots on final approach to runway 02 grass and asphalt and runway 31.

The maximum predicted ocular impact toward pilots on the remaining final approaches and the modelled visual circuits, is "low potential for after-image" (green glare). This corresponds to a "low" magnitude impact. No further mitigation is recommended.

The results of this assessment indicate that the Proposed Development does not introduce an unacceptable operational hazard to Brighton City Airport.

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Appendix A: Interim CAA Guidance on Solar Photovoltaic Systems

Interim CAA Guidance - Solar Photovoltaic Systems

BACKGROUND

1 Airport interest in solar energy is growing rapidly as a way to reduce operating costs and to demonstrate a commitment to renewable energy and sustainable development. In response, the CAA is seeking to develop its policy on the installation of Solar Photovoltaic (SPV) Systems and their impact on aviation. In doing so, it is reviewing the results of research having been carried out in the United States by the Federal Aviation Administration (FAA) culminating in the publication of Technical Guidance for Evaluating Solar Technologies on Airports and also reviewing guidance issued by other National Aviation Safety Administrations and Authorities on this subject.

2 On completion of the review, the CAA, together with the assistance of other aviation stakeholders, will develop a policy and provide formal guidance material on the installation of SPV, principally on or in the vicinity[1] of licensed aerodromes but will also include guidance on installations away from aerodromes (or 'en-route'[2]). This document therefore constitutes interim CAA guidance until a formal policy has been developed.

DISCUSSION

3 At present the key safety issue is perceived to be the potential for reflection from SPV to cause glare, dazzling pilots or leading them to confuse reflections with aeronautical lights. Whilst permission is not required from the CAA for any individual or group to shine or reflect a light or lights into the sky, SPV developers should be aware of the requirements to comply with the Air Navigation Order (ANO) 2009. In particular, developers and Local Planning Authorities (LPA) should be cognisant of the following articles of the ANO with respect to any SPV development regardless of location:

- Article 137 – Endangering safety of an aircraft.
- Article 221 – Lights liable to endanger.
- Article 222 – Lights which dazzle or distract.

4 The potential for SPV installations to cause electromagnetic or other interference with aeronautical Communications Navigational and Surveillance equipment (CNS) must be considered by the SPV developer, in coordination with the CAA, the aerodrome Air Traffic Service provider (ATS), the Air Navigation Service Provider (ANSP) and/or NATS and the MoD, as required.

[1] In this context, the term "in the vicinity" refers to officially safeguarded aerodromes noted in the Planning Circulars (see Paragraph 10) and a distance of up to 15km from the 'Aerodrome Reference Point' or the centre of the longest runway.
[2] SPV installations proposed further than 15km from an aerodrome are considered "en-route" developments, and may still require consultation with the CAA for an assessment on the impact, if any, to CNS equipment.

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5 Where SPV systems are installed on structures that, for example, extend above the roofline of tall buildings (either on, or 'off-aerodrome'), or where they are installed in the vertical plane (on plinths or towers), then there may be the potential for creating an obstacle hazard to aircraft and - in addition to the potential for creating turbulence hazard to aircraft - any infringement of the aerodrome Obstacle Limitation Surfaces (OLS) shall also need to be considered by the Aerodrome Licence Holder (ALH).

6 For all planned SPV installations it is best practice for the developer to consult with the operators of nearby aerodromes **before** any construction is initiated.

7 An ALH, in agreement with their LPA, may wish to initiate procedures so that it is only consulted on SPV planning applications at shorter distances from the aerodrome (for example within a 5 km radius), or at distances that would limit SPV development from within the aircraft operating visual circuit; however, this is at the discretion of the ALH and no CAA approval or endorsement of this decision is necessary.

RECOMMENDATIONS

8 It is recommended that, as part of a planning application, the SPV developer provide safety assurance documentation (including risk assessment) regarding the full potential impact of the SPV installation on aviation interests.

9 Guidance on safeguarding procedures at CAA licensed aerodromes is published within CAP 738 Safeguarding of Aerodromes and advice for unlicensed aerodromes is contained within CAP 793 Safe Operating Practices at Unlicensed Aerodromes.

10 Where proposed developments in the vicinity of aerodromes require an application for planning permission[3] the relevant LPA normally consults aerodrome operators or NATS when aeronautical interests might be affected. This consultation procedure is a statutory obligation in the case of certain major airports, and may include military establishments and certain air traffic surveillance technical sites. These arrangements are explained in Department for Transport Circular 1/2003 and for Scotland, Scottish Government Circular 2/2003.

11 In the event of SPV developments proposed under the Electricity Act, the relevant government department should routinely consult with the CAA. There is therefore no requirement for the CAA to be separately consulted for such proposed SPV installations or developments.

12 If an installation of SPV systems is planned **on**-aerodrome (i.e. within its licensed boundary) then it is recommended that data on the reflectivity of the solar panel material should be included in any assessment before installation approval can be granted. Although approval for installation is the responsibility of the ALH, as part of a condition of a CAA Aerodrome Licence, the ALH is required to obtain prior consent from CAA Aerodrome Standards Department **before** any work is begun or approval to the developer or LPA is granted, in accordance with the procedures set out in CAP 791 Procedures for Changes to Aerodrome Infrastructure.

13 During the installation and associated construction of SPV systems there may also be a need to liaise with nearby aerodromes if cranes are to be used; CAA notification and permission is not required.

[3] The CAA is aware of changes to planning legislation that may provide for 'Permitted Development Rights' for certain micro-generation equipment on both domestic and non-domestic property, under the General Permitted Development Order (1995).

14 The CAA aims to replace this informal guidance with formal policy in due course and reserves the right to cancel, amend or alter the guidance provided in this document at its discretion upon receipt of new information.

15 Further guidance may be obtained from CAA's Aerodrome Standards Department via aerodromes@caa.co.uk.

17 December 2010

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Appendix B: Technical Guidance for Evaluating Selected Solar Technologies on Airports (2018)

16. Abstract

"Airport interest in solar energy is growing rapidly as a way to reduce airport operating costs and to demonstrate a commitment to sustainable development. In response, the Federal Aviation Administration (FAA) has prepared Technical Guidance for Evaluating Selected Solar Technologies on Airports to meet the regulatory and informational needs of the FAA Airports organization and airport sponsors.

For airports with favourable solar access and economics, this report provides a checklist of FAA procedures to ensure that proposed photovoltaic or solar thermal hot water systems are safe and pose no risk to pilots, air traffic controllers, or airport operations. Case studies of operating airport solar facilities are provided, including Denver International, Fresno Yosemite International, and Albuquerque International Sunport."

Preface

"Over 15 airports around the country are operating solar facilities and airport interest in solar energy is growing rapidly. In response, the Federal Aviation Administration (FAA) has prepared this report, Technical Guidance for Evaluating Selected Solar Technologies on Airports, to meet the regulatory and information needs of FAA personnel and airport sponsors in evaluating airport solar projects.

The guidance is intended to provide a readily usable reference for FAA technical staff who review proposed airport solar projects and for airport sponsors that may be considering a solar installation. It addresses a wide range of topics including solar technology, electric grid infrastructure, FAA safety regulations, financing alternatives, and incentives.

Airport sponsors are interested in solar energy for many reasons. Solar technology has matured and is now a reliable way to reduce airport operating costs. Environmentally, solar energy shows a commitment to environmental stewardship, especially when the panels are visible to the traveling public. Among the environmental benefits are cleaner air and fewer greenhouse gases that contribute to climate change. Solar use also facilitates small business development and U.S. energy independence.

While offering benefits, solar energy introduces some new and unforeseen issues, like possible reflectivity and communication systems interference. The guidance discusses these issues and offers new information that can facilitate FAA project reviews, including a flow chart of FAA procedures to ensure that proposed systems are safe and pose no risks to pilots, air traffic controllers, or airport operations."

AIRPORTS AND SOLAR ENERGY: CHARTING A COURSE

"Though solar energy has been evolving since the early 1990's as a mainstream form of renewable energy generation, the expansion in the industry over the past 10 years and corresponding decrease in prices has only recently made it a practical consideration for airports. Solar energy presents itself as an opportunity for FAA and airports to produce on-site electricity and to reduce long-term electricity use and energy costs. While solar energy has many benefits, it does introduce some new and unforeseen issues, like possible glare (also referred to as reflectivity) and communication systems interference, which have complicated FAA review and approval of this technology. This guide discusses such issues and how FAA reviews for solar projects can be streamlined and standardized to a greater extent."

3.1.2 Reflectivity

"Reflectivity refers to light that is reflected off surfaces. The potential effects of reflectivity are glint (a momentary flash of bright light) and glare (a continuous source of bright light). These two effects are referred to hereinafter as "glare," which can cause a brief loss of vision, also known as flash blindness.

FAA Order 7400.2, Procedures for Handling Airspace Matters, defines flash blindness as "generally, a temporary visual interference effect that persists after the source of illumination has ceased."

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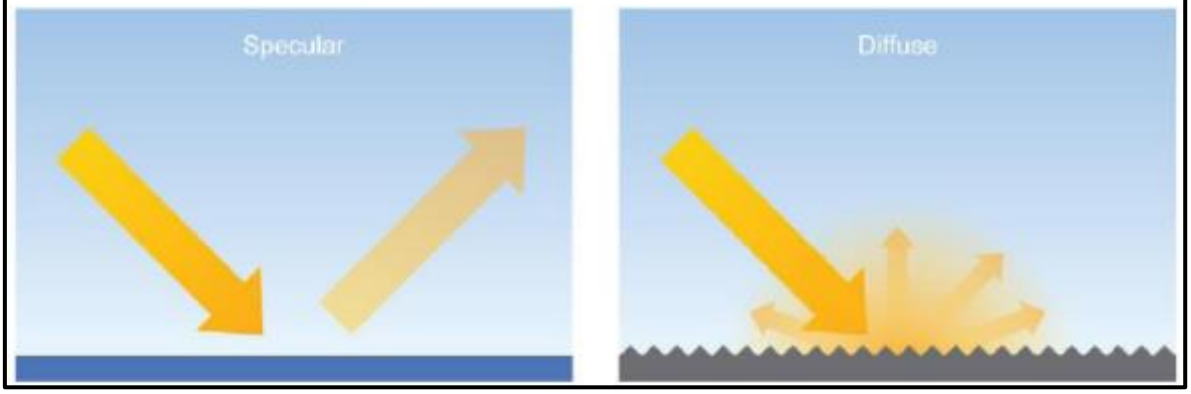
The amount of light reflected off a solar panel surface depends on the amount of sunlight hitting the surface, its surface reflectivity, geographic location, time of year, cloud cover, and solar panel orientation. As illustrated on Figure 16, flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.

Figure 16: Different Types of Reflection



CSP systems use mirrors to maximize reflection and focus the reflected sunlight and associated heat on a design point to produce steam, which generates electricity. About 90 percent of sunlight is reflected. However, because the reflected sunlight is controlled and focused on the heat collecting element (HCE) of the system, it generally does not reflect back to other sensitive receptors. Another source of reflection in a CSP system is the light that contacts the back of the HCE and never reaches the mirror. Parts of the metal frame can also reflect sunlight. In central receiver (or power tower) applications, the receiver can receive concentrated sunlight that is up to a thousand times the sun's normal irradiance. Reflections from a central receiver, although approximately 90% absorptive, can still reflect a great deal of sunlight.

Solar PV and SHW panels are constructed of dark, light-absorbing materials and covered with an anti-reflective coating designed to maximize absorption and minimize reflection. However, the glass surfaces of solar PV and SHW systems also reflect sunlight to varying degrees throughout the day and year. The amount of reflected sunlight is based on the incidence angle of the sun relative to the light-sensitive receptor (e.g., a pilot or air traffic tower controller). The amount of reflection increases with lower incidence angles. In some situations, 100% of the sun's energy can be reflected from solar PV and SHW panels.

Because solar energy systems introduce new visual surfaces to an airport setting where reflectivity could result in glare that can cause flash blindness to those that require clear, unobstructed vision, project proponents should evaluate reflectivity during project siting and design."

Completing an Individual Glare Analysis

"Evaluating glare for a specific project should be an iterative process that looks at one or more of the methodologies described below. Airport sponsors should coordinate closely with the FAA's Office of Airports to evaluate the potential for glint and glare for solar projects on airport property. These data should include a review of existing airport conditions and a comparison with existing sources of glare, as well as related information obtained from other airports with experience operating solar projects.

Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:

(1) A qualitative analysis of potential impact in consultation with the Air Traffic Control Tower, pilots, and airport officials

(2) A demonstration field test with solar panels at the proposed site in coordination with Air Traffic Control Tower personnel

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(3) A geometric analysis to determine days and times when there may be an ocular impact.

The FAA should be consulted after completing each of the following steps to determine if potential reflectivity issues have been adequately considered and addressed.

The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design."

3. Assessing Baseline Reflectivity Conditions

"Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare."

2. Tests in the Field

"Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction."

3. Geometric Analysis

"Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts. Figure 17 provides an example of such a geometric analysis (not shown).

Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far you need to be from a solar reflected surface to avoid flash blindness. It is known that this distance is directly proportional to the size of the array in question23 but still requires further research to definitively answer.

The FAA Airport Facilities Terminal Integration Laboratory (AFTIL), located at the William J. Hughes Technical Centre at Atlantic City International Airport, provides system capabilities to evaluate control tower interior design and layout, site selection and orientation, height determination studies, and the transition of equipment into the airport traffic control tower environment. AFTIL regularly conducts computer assessments of potential penetrations of airspace for proposed airport design projects and has modelled the potential characteristics of glare sources, though not for solar projects. AFTIL may be a resource for regional FAA officials and sponsors who seek to evaluate the potential effects of glare from proposed solar projects."

Experiences of Existing Airport Solar Projects

"Solar installations are presently operating at a number of airports, including megawatt-sized solar facilities covering multiple acres. Air traffic control towers have expressed concern about glint and glare from a small number of solar installations. These were often instances, where solar installations were sited between the tower and airfield, or for installations with inadequate or no reflectivity analysis. Adequate reflectivity analysis and alternative siting addressed initial issues at those installations."

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Appendix C: Assumptions, Limitations & Fixed Model Variables

1. The sun position and glare analysis will be determined throughout the year on a 1-minute basis.
2. The maximum amount of solar power striking surface normal to the sun per unit area (Peak direct normal irradiance, DNI) is set at 1,000 W/m^2. This will be scaled for each time step to account for changing sun position.
3. The average subtended angle of the sun as viewed from earth is 9.3 mrad.
4. The ocular transmission coefficient for the radiation that is absorbed in the eye before reaching the retina, is set to 0.5.[11,12]
5. Observer pupil diameter is set at the typical value of 0.002 m for daylight.[11,12]
6. Eye focal length for the distance between the nodal point (where rays intersect in the eye) and the retina is set at the typical value of 0.017 m. [11,12]
7. The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, models have been validated against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.[13]
8. The algorithm assumes that the PV array is aligned with a plane defined by the total heights (ground elevation plus PV array height) of the coordinates outlined in the Google map.
9. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors. As such, calculated DNI may vary from actual DNI experienced by observer.
10. The system output calculation is a DNI-based approximation that assumes clear, sunny skies all year-round.
11. Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
12. Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
13. Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
14. PV array tracking assumes the modules move instantly when tracking the sun, and when reverting to the rest position.

[11] Ho, C. K., Ghanbari, C. M., and Diver, R. B., 2011, Methodology to Assess Potential Glint and Glare Hazards From Concentrating Solar Power Plants: Analytical Models and Experimental Validation, ASME J. Sol. Energy Eng., 133.
[12] Sliney, D.H. and B.C. Freasier, 1973, Evaluation of Optical Radiation Hazards, Applied Optics, 12(1), p. 1-24.
[13] https://www.forgesolar.com/help/#assumptions

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