

AFL Architects Ltd

Manchester Royal Infirmary

Glint and Glare Study

Reference: LTG001

02 | 13 February 2026

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Job number 314676-00

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Subject	Addendum
Job No/Ref	314676-00
Date	15 February 2026

1. Purpose of Addendum

The report reference LTG001 'Glint and Glare Study' dated 6 February 2026 identified one SPV, using the SGHAT assessment, which had a low potential for temporary after-image. This SPV is located on the roof of the Patrick Cryne Building.

Therefore, mitigation has been considered and will be included in the final scheme. This addendum outlines the mitigation.

1.1 Cause of the temporary after image

The SPV array located on the roof of the Patrick Cryne Building (Figure 1).

Figure 1: Site plan



The SPV on this building comprises a triangular section arrangement (Figure 3) of SPVs arranged on three roof areas. The area resulting in the temporary after image is identified in red in Figure 2.

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Figure 2 Proposed SPV layout and orientations (Patrick Cryne Building)

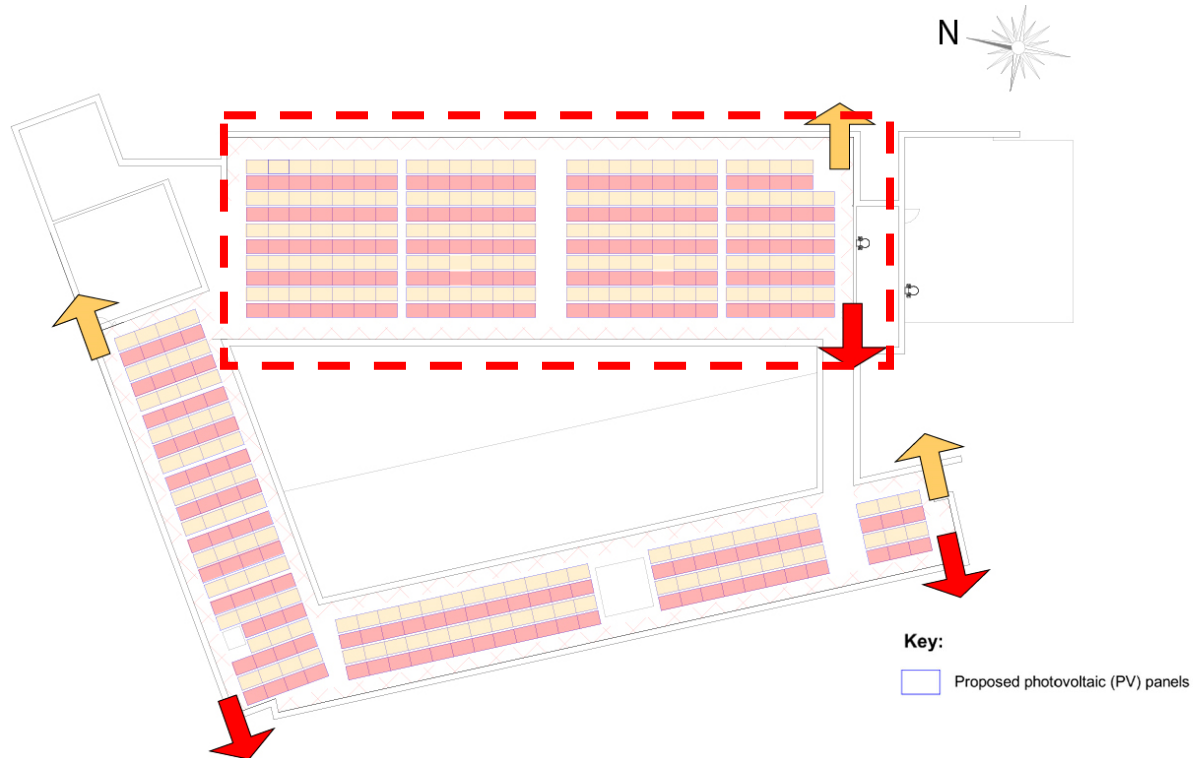
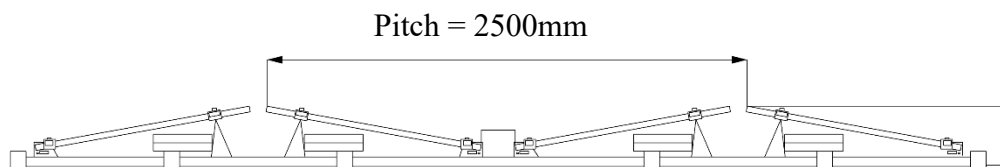


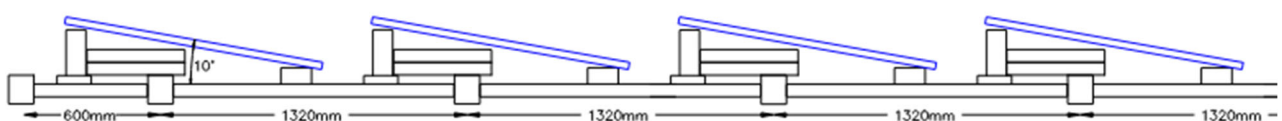
Figure 3 Proposed SPV section (Patrick Cryne Building)



The SPVs causing the reflections are tilted 10° towards the west (described as PCB05 in the report appendix). The SPVs tilted 10° towards the east were not found to result in an after image (described as PCB02 in the report appendix).

Therefore, an alternative arrangement is proposed for the west facing panels. All panels will be titled 10° to the east (Figure 4) to match the performance of PCB02, which was not identified to cause an after image in the original study.

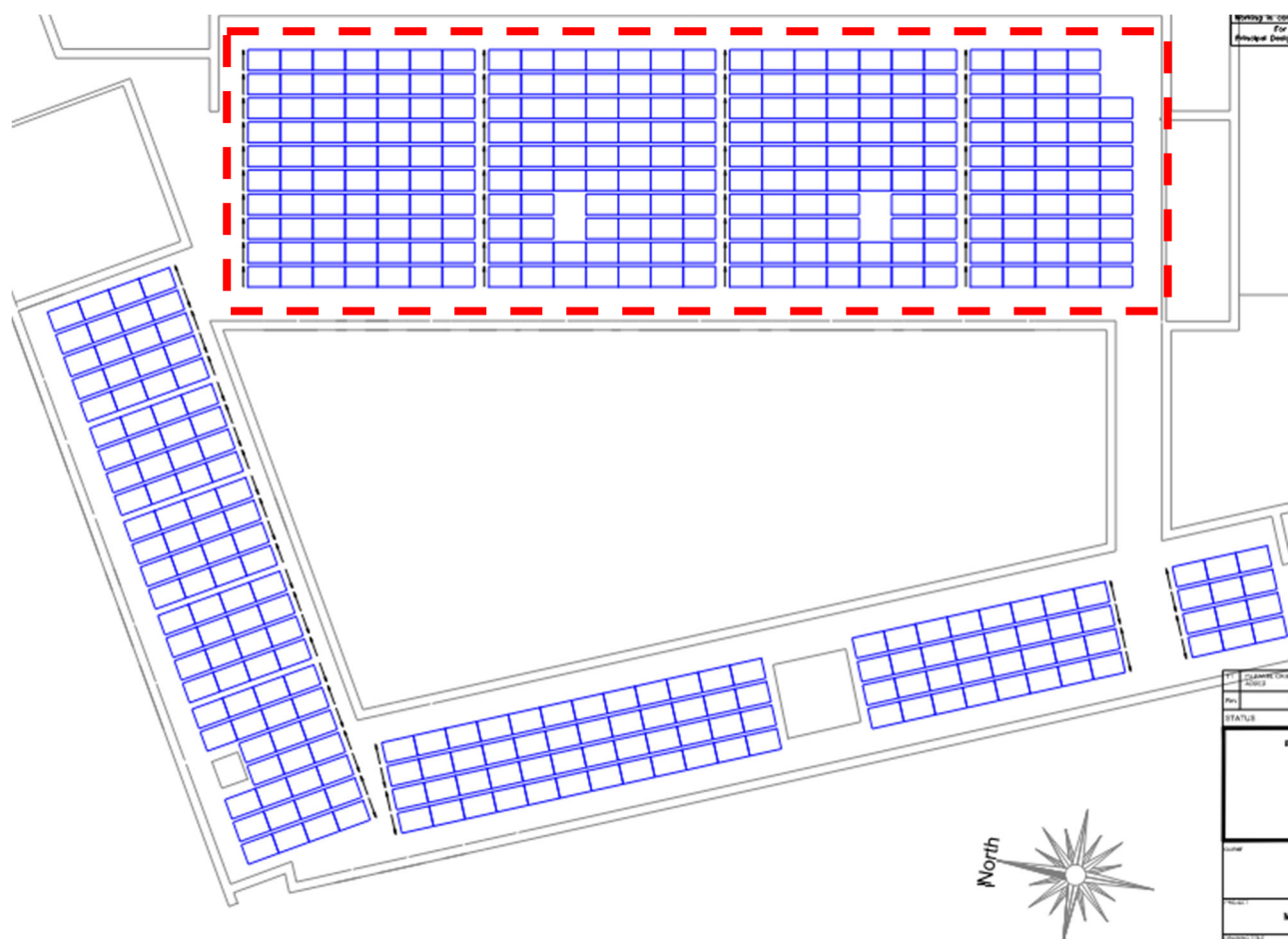
Figure 4 New proposed arrangement for SPV section (Patrick Cryne Building), panels tilted to east



This arrangement is described on the following layout plan, Figure 5.

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Figure 5 Revised layout plan for SPV section (Patrick Cryne Building)



By comparison of Figure 2 and Figure 5, it can be seen that the orientation and tilt direction of the smaller areas of SPV are unchanged in the mitigated solution.

The final arrangement is described in further detail on the following drawings

- M1856-E01 T1 Patrick Cryne
- M1856-E02 T1 Patrick Cryne
- MRIPI-AFL-ZZ-RF-DR-A-20101-Proposed Roof Plan - Patrick Cryne Building (K57-01)-P03

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2. Conclusion

The SGHAT assessment has determined that a low potential for temporary after-image effects for all the assessed SPV arrays and journeys exists. It is concluded that the adjustments made to PCB05 (the west facing SPVs) so that they are now all east facing will mitigate the potential for after-images.

Based on the findings of the assessment, and this addendum, no further mitigation measures are deemed necessary to the proposed solar photovoltaic (SPV) panels on the roof of the Patrick Cryne Building, Clinical Science Building and Peter Mount Building in accordance with the latest CAA and FAA guidance.

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Appendices

Appendix A

A-1

Executive Summary

Arup has undertaken a Glint and Glare assessment in line with current CAA/FAA guidance to assess for potential impact of the proposed solar photovoltaic (SPV) installation on helicopter pilots using the Manchester Royal Infirmary (MRI) helipad, in terms of reflected solar glare effects.

The assessment has been carried out in two stages:

- Stage 1 - Geometric modelling: Modelling of reflected sunlight and intersection with flight paths and ground viewing positions to establish when and where reflected sunlight from the SPV panels has the potential to enter the cockpit of the helicopter. Geometric modelling does not quantify the risk of glint and/or glare, but identifies the potential for any risk of reflected solar glare.
- Stage 2 - Solar Glare Hazard Analysis Tool (SGHAT) analysis tool: Quantification of risk level of glint and/or glare for the take-off and landing activities with a solar glare hazard analysis.

The analysis is based on SPV design information provided by AFL Architects which describes the location, orientation and inclination of the SPVs on three buildings. Should there be any deviations from this specification occur in the future, the design may need to be re-assessed confirm the validity of the results of this assessment as summarised below.

The geometric modelling indicates:

- Reflected sunlight from the proposed SPV installations will be visible from helicopter flight paths (Normal Approach Profile and Obstruction Surface).

The SGHAT assessment has determined that a low potential for temporary after-image effects for the majority of assessed SPV arrays, with a potential for temporary after-image effects identified in relation to the PCB05 SPV array.

Based on the findings of the assessment no mitigation measures are deemed necessary to the proposed solar photovoltaic (SPV) panels on the roof of the Patrick Cryne Building (except PCB05), Clinical Science Building and Peter Mount Building in accordance with the latest CAA and FAA guidance.

1. Introduction

1.1 Scope of Report

Arup was commissioned to carry out a glint and glare study to assess any potential impact of the proposed solar photovoltaic (SPV) installation associated with Manchester Royal Infirmary (MRI) helipad.

This document provides a detailed site-specific analysis of the potential for reflected sunlight from the proposed SPV installation and whether this could constitute a risk to the helicopter flight paths.

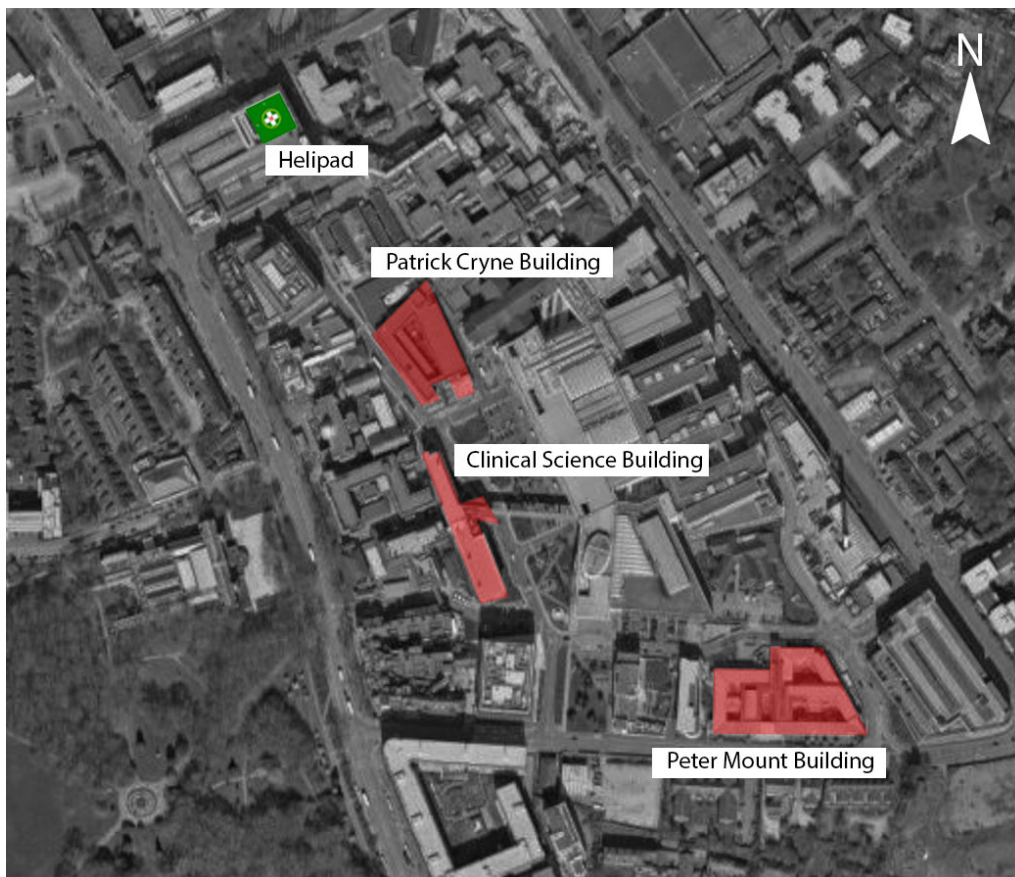
This document details the methodology and findings of the assessment.

1.2 The Project

The proposed project involves the installation of SPV panels across several roof areas within the Manchester Royal Infirmary (MRI) site. SPV panels are proposed to be installed on the roof of the Patrick Cryne Building, Clinical Science Building, and Peter Mount Building. Further details of the proposed SPV installation are provided in Section 1.4. Figure 1 shows the site plan and buildings where SPV installations are proposed.

The helipad is located on the roof of the multi-storey car park on Grafton Street. The Patrick Cryne Building is the closest to the helipad, the Clinical Science Building is located further to the south-east of the helipad and the Peter Mount Building is the furthest from the helipad.

Figure 1: Site plan



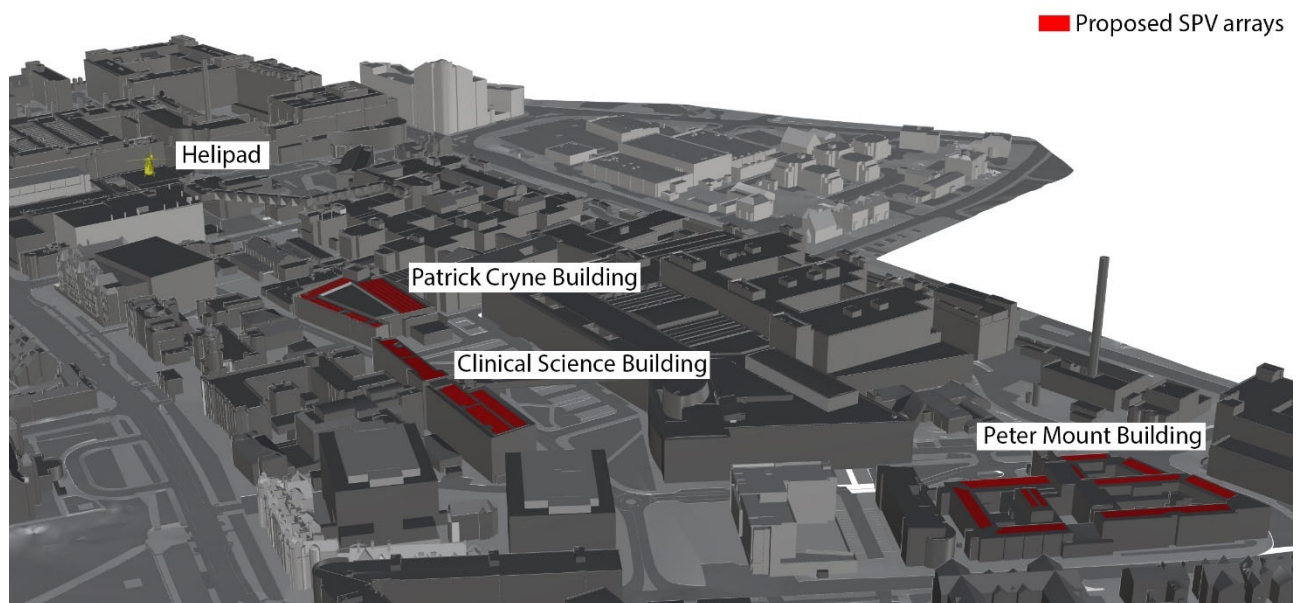
1.3 Data Sources

The 3D model of the surrounding massing and landscape was provided by Arup and comprises the following elements:

1. Local geometry of adjacent buildings
2. Local terrain and roads

A view of the combined 3D model is shown in Figure 2.

Figure 2 Perspective view of the proposed SPV arrays and 3D model



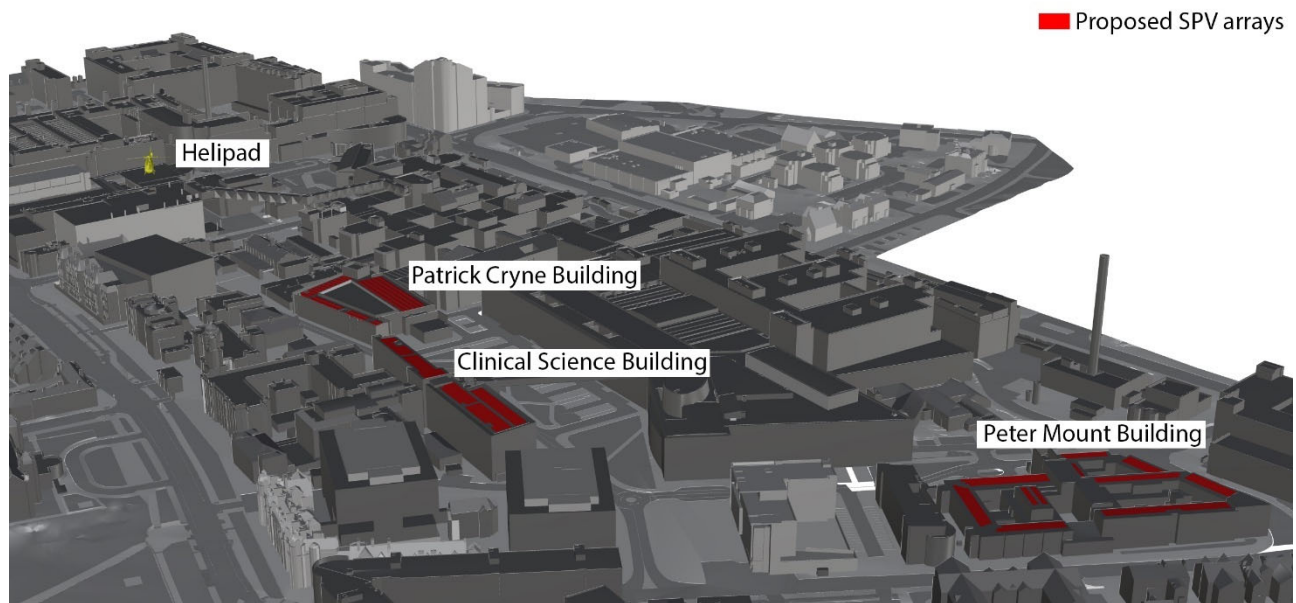
Information provided by AFL Architects included:

- Proposed roof plan, elevations and sections for Patrick Cryne Building, Clinical Science Building and Peter Mount Building (Roof Plan updated- Elevations.dwg)
- M1856 - MRI CSB 2 Specification.pdf
- M1856 - MRI CSB 3 Specification.pdf
- M1856 - MRI Patrick Cryne Specification.pdf
- M1856 - MRI Peter Mount Specification.pdf

1.4 Proposed SPV Installation

The proposed SPV array will be mounted on the roofs of the Patrick Cryne Building, Clinical Science Building and Peter Mount Building, situated to the south-east of the helipad at approximate distances of 170m, 270m and 510m respectively.

Figure 3 Proposed SPV arrays



Patrick Cryne Building: SPV panels are mounted on the building roof with a tilt of 10° above horizontal. The proposed SPV orientations are shown in Figure 4 (colours indicate the direction of inclination).

Figure 4 Proposed SPV layout and orientations (Patrick Cryne Building)

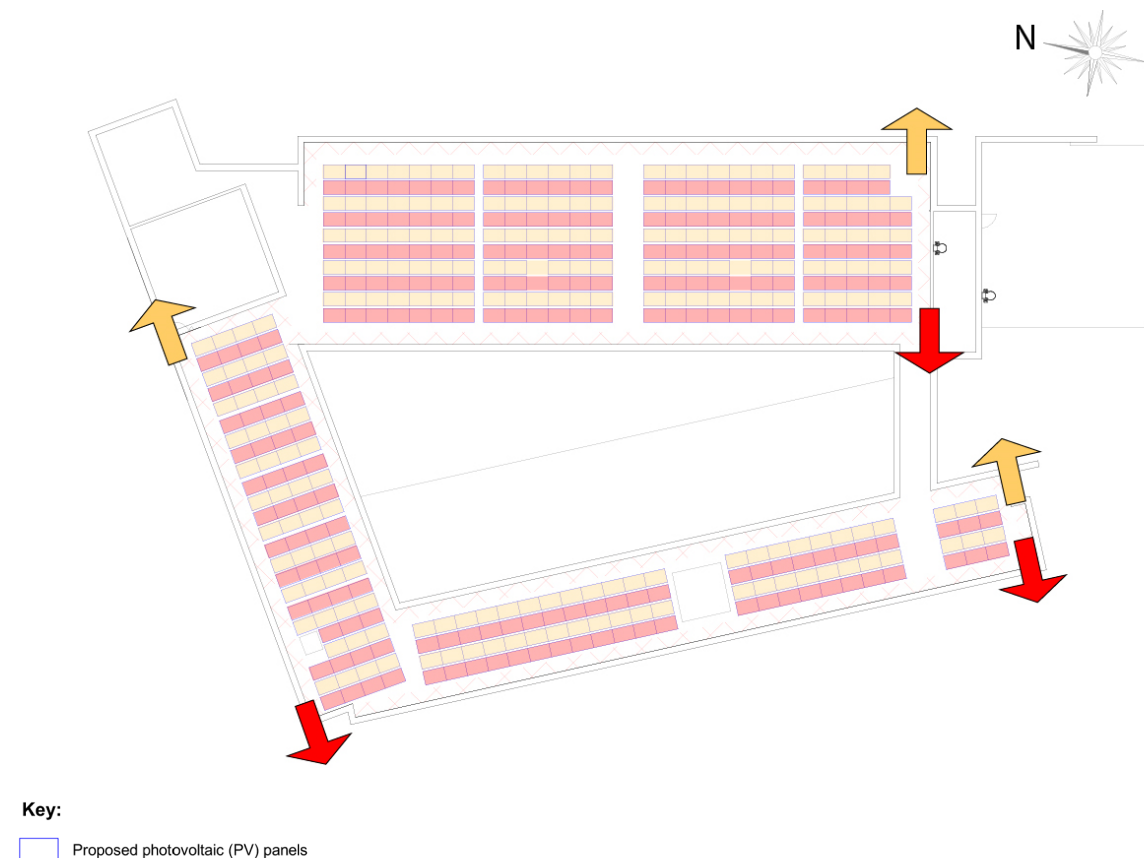
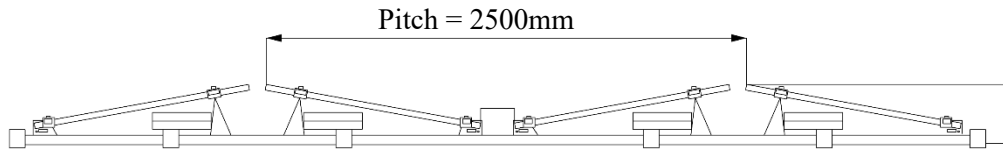
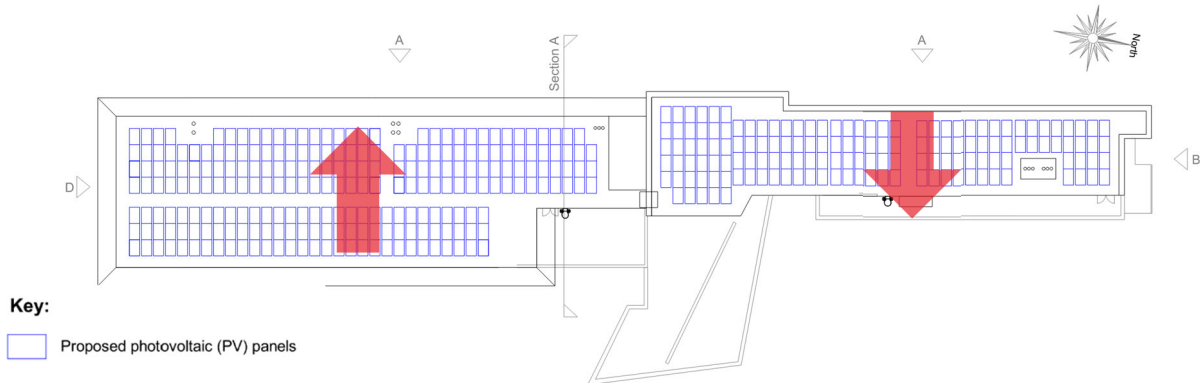


Figure 5 Proposed SPV section (Patrick Cryne Building)



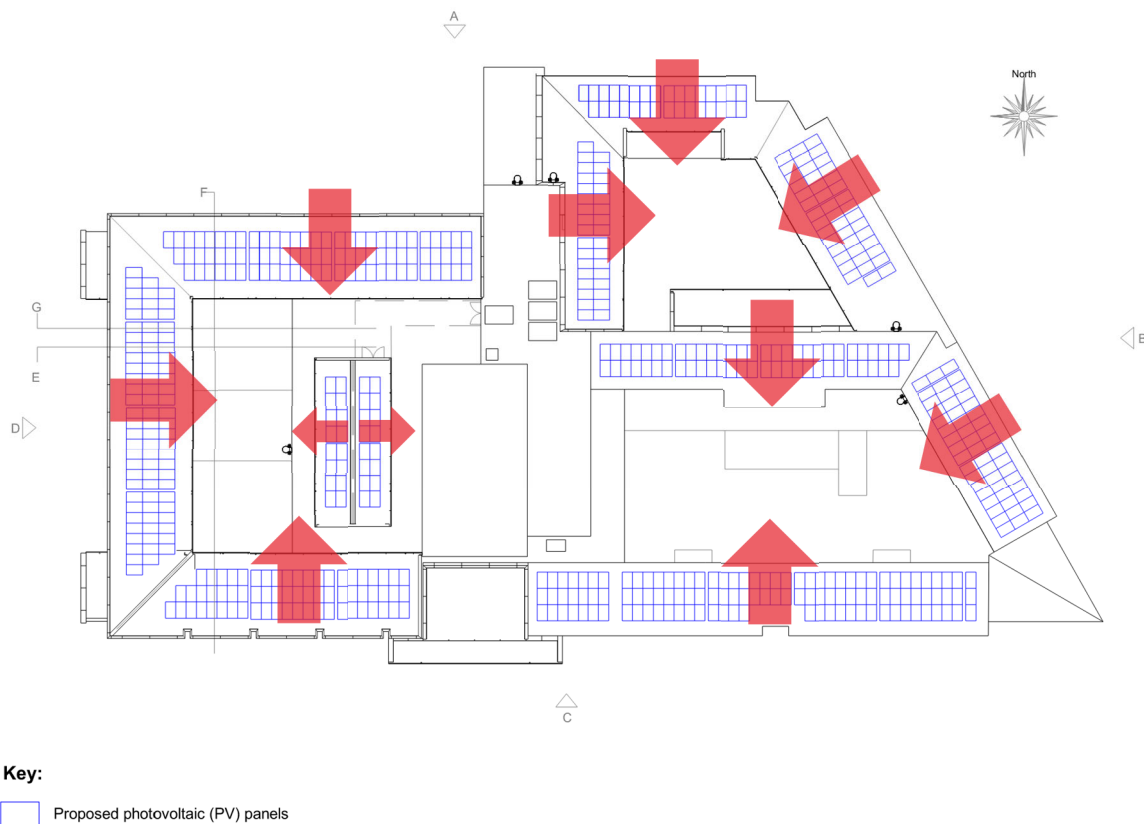
Clinical Science Building: SPV panels are mounted on the building roof with a tilt of 4° above horizontal. The proposed SPV orientations are shown in Figure 6.

Figure 6 Proposed SPV layout and orientations (Clinical Science Building)



Peter Mount Building: SPV panels are mounted on the building roof with a tilt of 4° above horizontal. The proposed SPV orientations are shown in Figure 7.

Figure 7 Proposed SPV layout and orientations (Peter Mount Building)



The assessment has been undertaken assuming a smooth glass SPV panel with anti-reflective coating.

Figure 8 Example SPV array installations



1.5 Helicopter Approach

The helipad is located in an urban setting at the top an existing carpark (Figure 1). The size and design of the helipad is governed by Civil Aviation Publication (CAP) 1264 produced by the Civil Aviation Authority.

The helicopter is the EC135-T2 (Figure 9), and its specification and design result in a Final Approach and Take Off (FATO) area and a safety perimeter with no protruding objects.

The diagram in Figure 10 shows the required slope of no less than 2% radiating from the FATO to a distance of approximately 3.5km (to achieve a height of 152m above the level of the FATO) to establish suitable approach paths. There should be no obstructions protruding through the slope.

Figure 11 describes the specified suitable routes for approach and take off coloured in green. As it can be seen in the diagram there are some segments omitted. These segments have been omitted due to obstructions on the approach.

Figure 9 Helicopter



Figure 10 Approach Surface Diagram

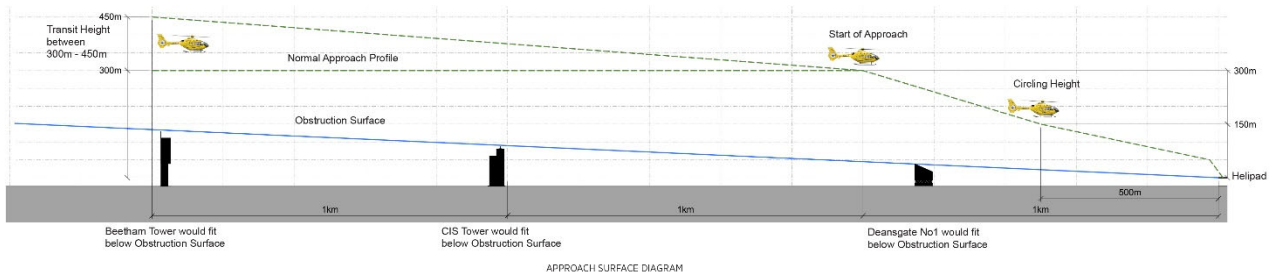


Figure 11 Approach Diagram (left) and local development boundary (right)



The helicopter can travel freely within approach zone, with infinite variations in approach routes. The modelling will therefore focus on the Normal Approach Profile described in Figure 10 and the worst-case Obstruction Surface (i.e. the lowest possible approach altitude). These routes are described in 3D in Figure 12, the Obstruction Surface (blue) and Normal Approach Profile (green) are shown within a diameter of 1km around the proposed development site.

Figure 12 Obstruction Surface and Normal Approach Profile

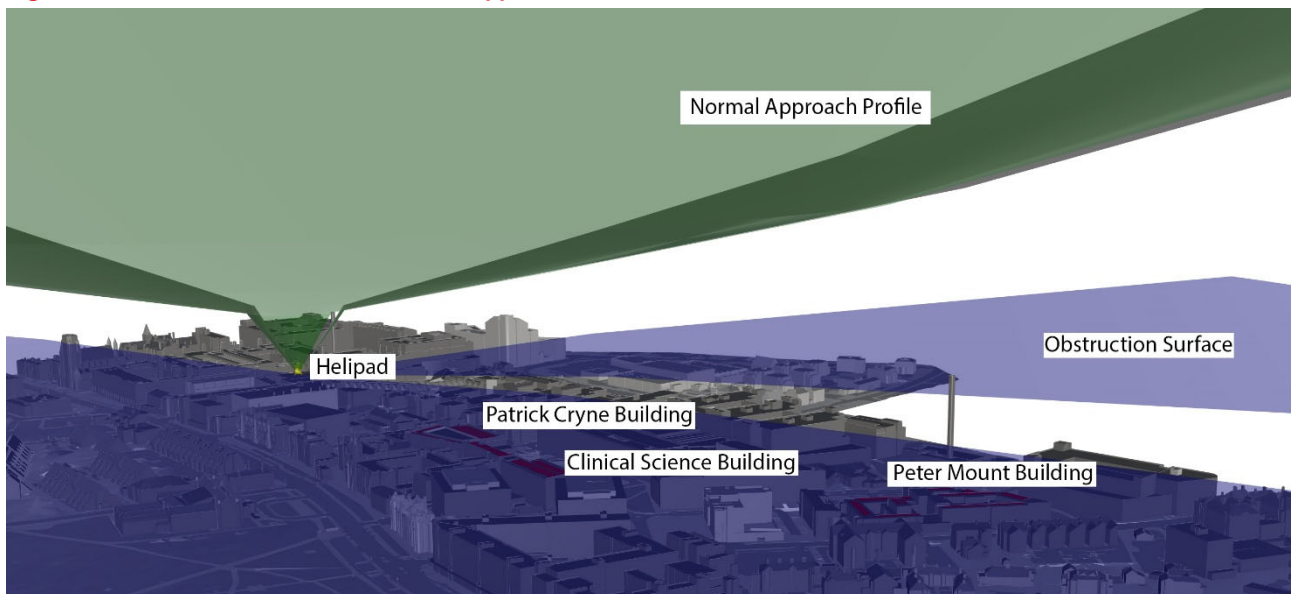
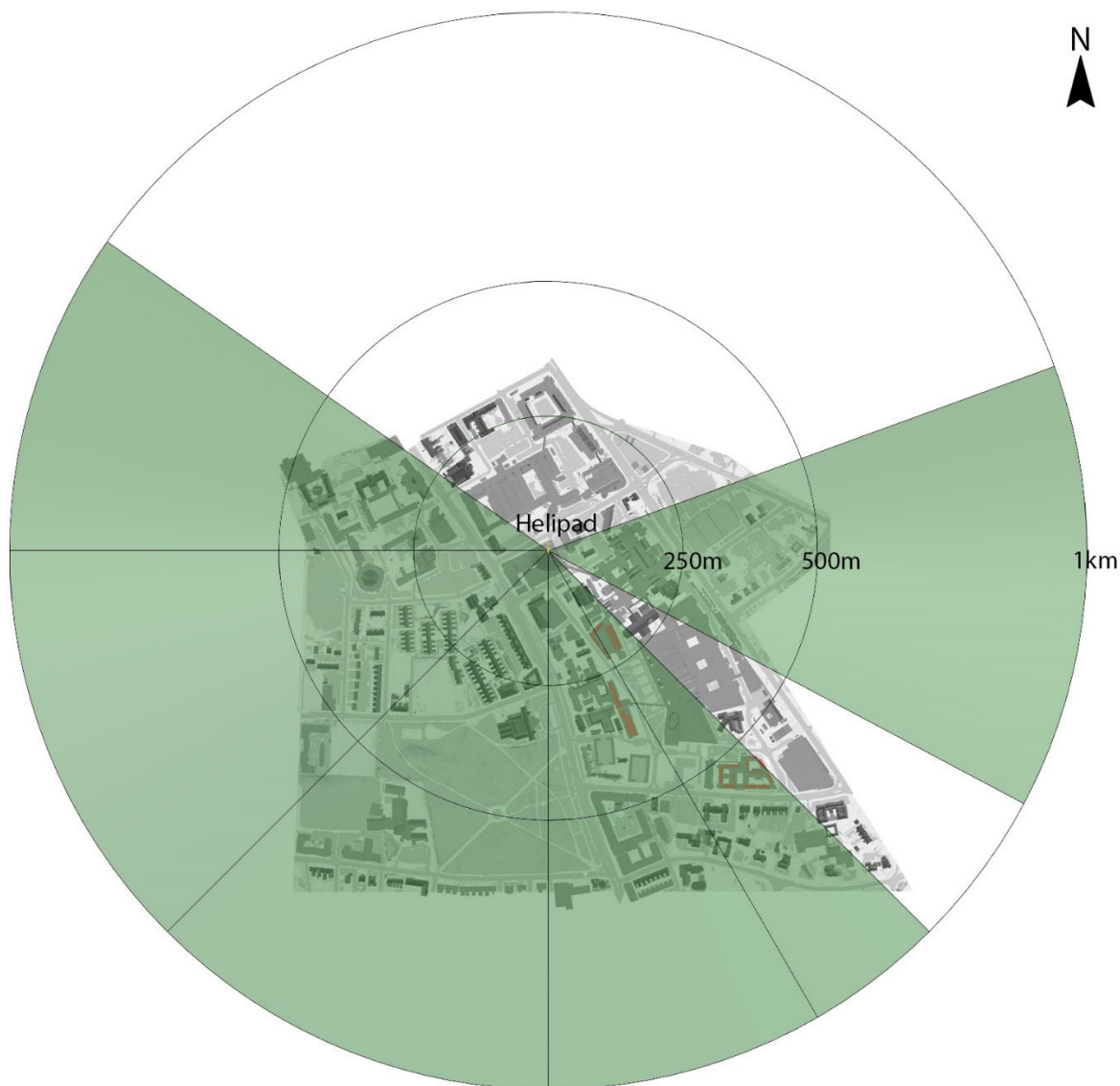


Figure 13 Plan view of Normal Approach Profile



1.6 Guidance

At present, the Civil Aviation Authority (CAA) does not issue specific criteria against which SPV installations can be accessed. However, in 2010 the CAA published 'Interim CAA Guidance - Solar Photovoltaic Systems' which acknowledges the potential safety issues which could be caused by SPV installations in close proximity to airports:

'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.'

'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.’*

The CAA guidance recommends 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. The CAA guidance references guidance on safeguarding procedures at CAA licenced aerodromes within CAP 738 Safeguarding of Aerodromes.

The Airport Operators Association ‘Safeguarding of Aerodromes Advice Note 5 – Renewable Energy and Impact on Aviation’, which was published (2016) in collaboration with the CAA, outlines:

‘Solar energy provision has the potential to produce reflectivity (glint and glare). Reflectivity Assessments may be needed to measure the potential of glare and/or flash blindness. The CAA endorses the Federal Aviation Authority (FAA) interim policy titled ‘FAA for Solar Energy System Projects’. For assessment it is recommended to use the ‘Sandia Solar Glare Hazard Analysis Tool or carry out an equivalent assessment.’

The Solar Glare Hazard Analysis Tool (SGHAT) summarises the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276 as:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles.
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cabin height.

In May 2021, the FAA published a final policy titled ‘Review of Solar Energy System Projects on Federally Obligated Airports’ which replaced the Interim Policy published in 2013. The FAA has concluded that for Pilots on final approach the glint and glare experienced for SPV is similar to that routinely experienced from other reflecting bodies (water, glass façade buildings etc). as a result, the policy now focuses on potential glint and glare to ATCTs only. They now only ask an airport to confirm that there is no potential for ocular impact to the ATCT. The FAA also removed the requirement for use of a Solar Glare Hazard Analysis Tool (SGHAT) which was previously mandated. Whilst the FAA are not discouraging the use of a SGHAT, simply that, it is not mandated for use.

1.7 Glint and Glare

Glint is defined as a momentary flash of bright light often caused by a reflection off a moving source, for example a moving car.

Glare is defined as a continuous source of bright light and is generally associated with stationary objects, which, due to the slow relative movement of the sun, reflect sunlight for a longer duration.

The difference between glint and glare is **duration**. Industry-standard glare analysis tools evaluate the occurrence of glare on a minute-by-minute basis; accordingly, they generally refer to solar hazards as 'glare'.

1.8 Process

The analysis of reflected sunlight from the proposed SPV array has been broken down into two stages with Stage 2 undertaken if Stage 1 identifies a need for further assessment:

- Stage 1 - Geometric modelling - Modelling of reflected sunlight and intersection with flight paths to establish when and where reflected sunlight from the SPV panels has the potential to enter the cockpit of helicopter. Geometric modelling does not quantify the risk of glint and and/or glare.

- Stage 2 - SGHAT analysis tool - Quantification of risk level of glint and/or glare for flight paths the solar glare hazard analysis. Stage 2 is only undertaken if the stage 1 geometric assessment identifies a potential risk.

2. Stage 1 - Geometric Modelling

2.1 Methodology

Geometric modelling has been undertaken in four steps:

- Modelling of the sun movements for the site location.
- Modelling of the reflected sunlight from the proposed SPV array.
- Modelling of flight paths.
- Intersection of reflected sun light modelling and flight paths.
- Interpretation of intersections and identification of situations where reflected sunlight has the potential to enter the cockpit.

2.1.1 Establishing Areas of Potential Glare

Only reflected sunlight entering the cockpit will have the potential to affect the safety critical vision of the aircrew. Essentially, if the aircrew cannot see the SPV array from typical seating positions, there will be no risk of glare.

Detailed analysis of the intersection between flight path models and the reflected sunlight cone was undertaken.

The analysis considers the following elements to identify if, where and when reflected sunlight has the potential to enter the cockpit:

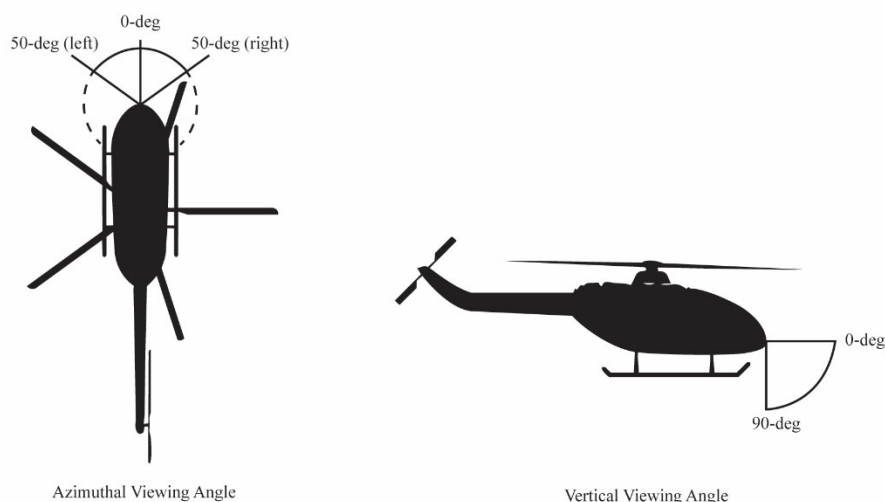
- Position and direction of travel of the helicopter.
- Visibility of SPV array from the flight deck; determined by the Cockpit Cut-off Angle.

Aircrew have vision limited by the cockpit and helicopter construction, this is described as an angle, known as the cockpit cut-off angle. The cockpit cut-off angle is defined as the angle between the longitudinal axis of the aircraft fuselage and an inclined plane below, up to the limit at which the pilot can view.

The cut off angles assumed in the interpretation of the geometric modelling are as follows and as illustrated in Figure 14:

- The azimuthal viewing angle is taken to be 50° to the left and right field-of-view of the pilot during approach. A view angle of 180° implies the pilot can see glare emanating from behind the plane. A view angle of 50° implies the pilot has a field-of-view of 50° to their left and right during approach, i.e. a total FOV of 100°.
- The vertical viewing angle of 90° is applied. A value of 90° assumes the pilot can see glare appearing directly underneath the helicopter.

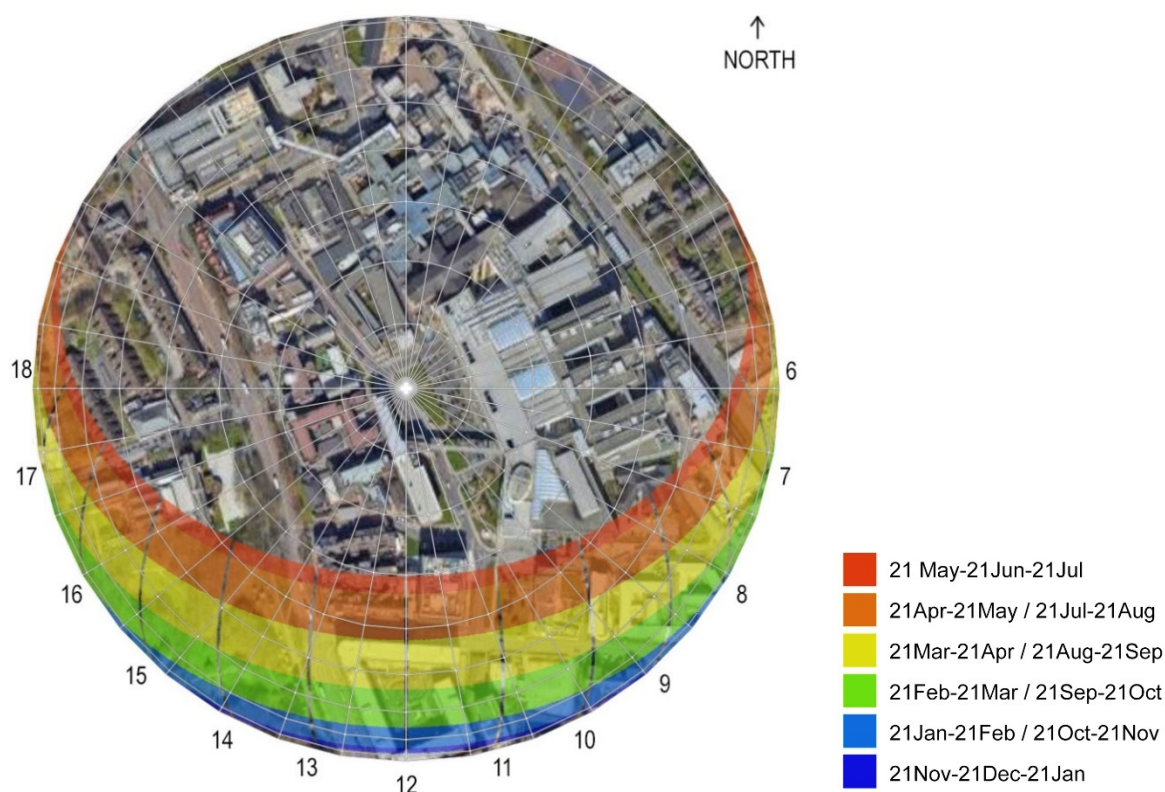
Figure 14 Helicopter field-of-view defined by azimuthal and vertical viewing angle parameters



2.2 Modelling of Reflected Sunlight Cone

The objective of the sunpath analysis is to establish if reflections may transect the flight path and be observed in the field of view of the train driver. The sunpath is defined as the movement of the sun in the sky over the site (Figure 15) and considers the annual trajectory of the sun overhead. Figure 15 show the annual sunpath and each coloured cell represents one hour of each day/month.

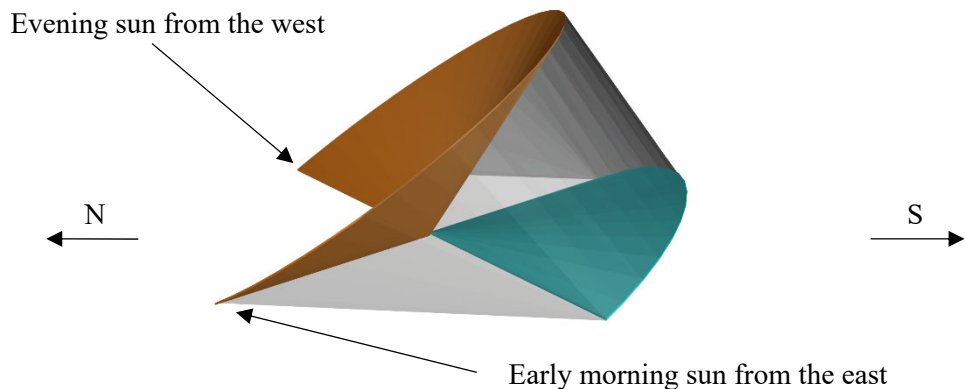
Figure 15 Sunpath diagram: sunpath over the sky during the year



The movement of the sun through summer, winter solstices along with mid-season equinox has been modelled within the 3D software. These represent the extremes of sun azimuth and altitude and provide the bounding criteria for the annual sun position, i.e. the position of the sun for all other times of the year will fall within the two solstice sunpath lines.

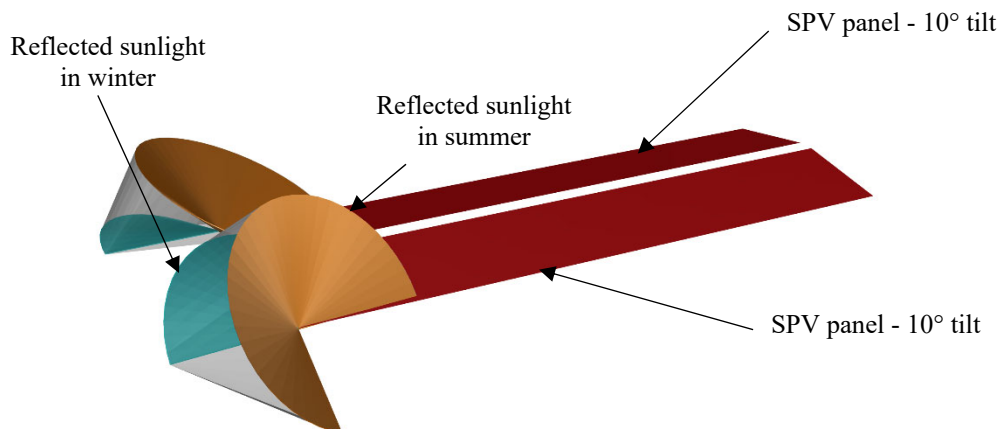
- Low angle winter sun (winter solstice 21st December) – Blue.
- High angle summer sun (summer solstice 21st June) – Orange.

Figure 16 Sunlight falling onto SPV panels



Sun rays have been traced from the solstice sun positions to the SPV panel, establishing the extent and depth of reflection from the proposed SPV panel. The reflected rays were modelled to create a bounded cone, a volume representing the path of all reflected sunlight from the SPV array. Separate reflected sunlight volumes have been created for each of the SPV panels to reflect the relative tilt and orientation angles.

Figure 17 Example - area of reflected sunlight from proposed SPV panels (Patrick Cryne Building) with a tilt of 10° above horizontal.



2.3 Intersection with Flight Paths

Geometric representations of the following scenarios have been modelled:

- Normal Approach Profile
- Obstruction Surface

These models have been overlaid with the reflected sunlight cone to understand where reflected sunlight and air traffic may coincide.

Intersections between the cone and the flight paths represent where aircraft could potentially coincide with reflected sunlight at some point within a yearly solar cycle. The intersection of the flight path and the reflected sunlight cone does not necessarily represent a risk of potential glare.

2.4 Reflected Sunlight Cone

A simplified form of the reflected sunlight from the SPV array as a whole has been created by positioning a 'area of reflection model' in each corner and combining these areas together.

While the SPV array comprises numerous individual panels, their size and close spacing, driven by the scale and goal of maximising their density, will minimise the gaps' visibility from an aerial perspective.

2.5 Interpretation of Geometric Visual Model

A geometric visual analysis has been undertaken to interpret the results of the reflected sunlight cone and flight path intersection modelling. It has been found that:

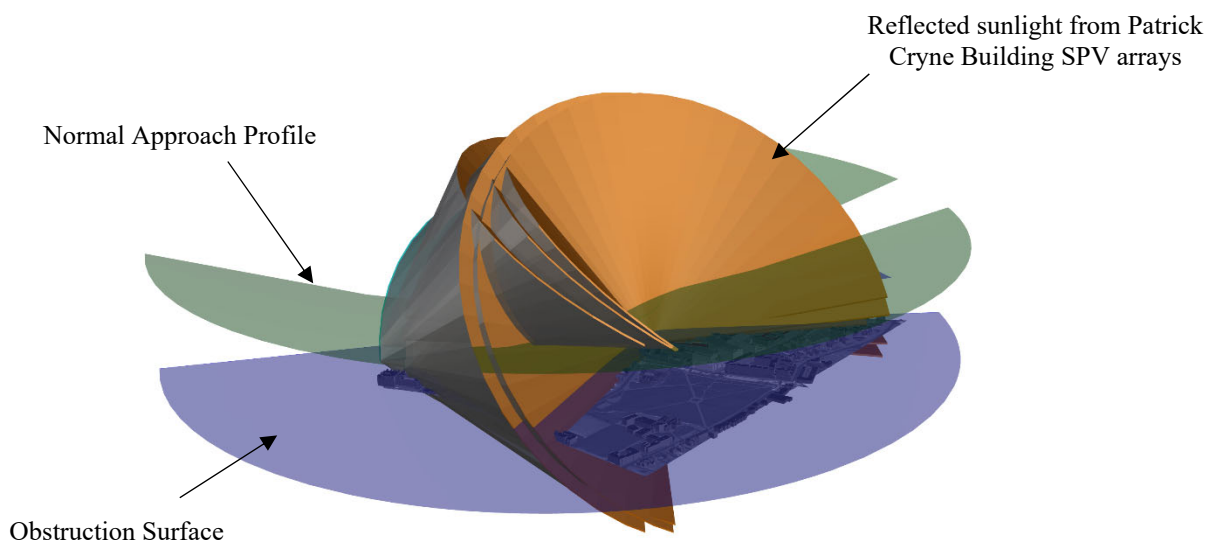
- There are instances when reflected sunlight is visible from the helicopter. These instances occur along the Normal Approach Profile and Obstruction Surface.

The following diagrams show the results of this preliminary assessment. As reflections which are visible from the helicopters have been found, it is necessary to carry out the Stage 2 by using the SGHAT analysis tool.

2.5.1 Patrick Cryne Building

The geometric analysis indicates that there is intersection between the reflected sunlight from Patrick Cryne Building SPV installations and helicopter flight paths (Normal Approach Profile and Obstruction Surface) as shown in Figure 18.

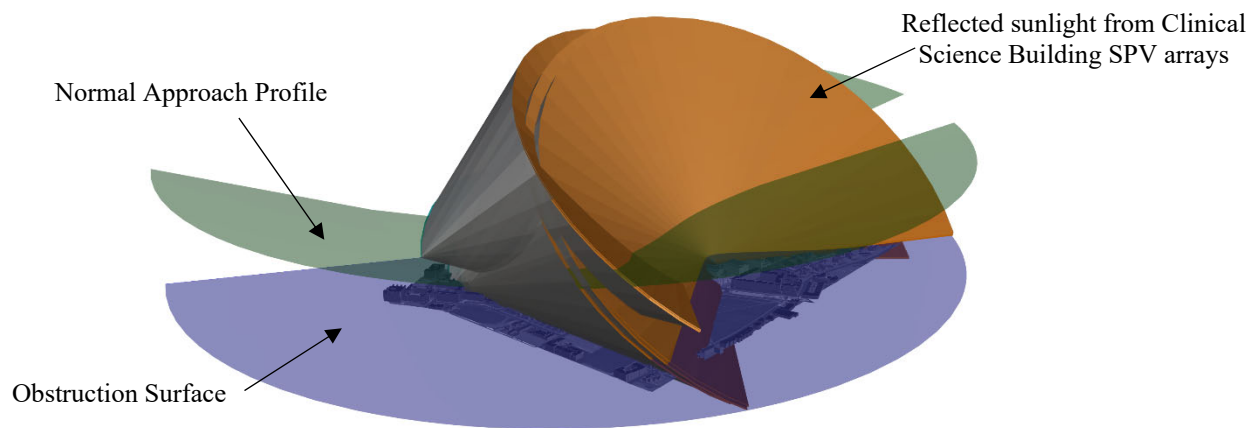
Figure 18 Intersection of reflected sunlight from Patrick Cryne Building proposed SPV installation Normal Approach Profile and Obstruction Surface



2.5.2 Clinical Science Building

The geometric analysis indicates that there is intersection between the reflected sunlight from Clinical Science Building SPV installations and helicopter flight paths (Normal Approach Profile and Obstruction Surface) as shown in Figure 19.

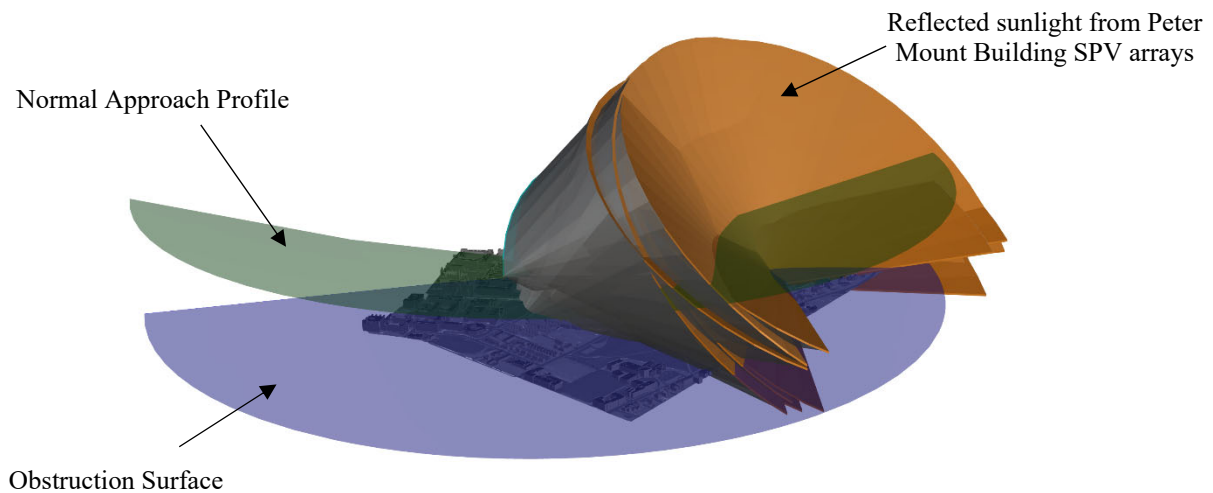
Figure 19 Intersection of reflected sunlight from Clinical Science Building proposed SPV installation Normal Approach Profile and Obstruction Surface



2.5.3 Peter Mount Building

The geometric analysis indicates that there is intersection between the reflected sunlight from Peter Mount Building SPV installations and helicopter flight paths (Normal Approach Profile and Obstruction Surface) as shown in Figure 20.

Figure 20 Intersection of reflected sunlight from Peter Mount Building proposed SPV installation Normal Approach Profile and Obstruction Surface



3. Stage 2 - SGHAT analysis tool

3.1 Methodology

Quantification of potential glint and glare has been undertaken using the Solar Glare Hazard Analysis Tool (SGHAT) ‘*GlareGauge*’ developed by Sandia National Laboratories and licenced by Forge Solar. The tool can be used to determine when and where solar glare can occur throughout the year from a specified SPV array, as viewed from defined observation points and routes.

The tool meets the United States Federal Aviation Authority (FAA) glare analysis requirements as defined 78 FR 63276 ‘Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports’. The FAA, in cooperation with the United States Department of Energy (DOE), has adopted the Sandia SGHAT tool as the standard for measuring the ocular impact of proposed SPV arrays on air traffic.

Though FAA guidance and regulations have no jurisdiction in relation to safeguarding of airspace over the UK, the background research and findings developed by Sandia National Laboratories have a global relevance. In addition, the Airport Operators Association (AOA) ‘Safeguarding of Aerodromes Advice Note 5 – Renewable Energy an Impact on Aviation’ published in 2016 in collaboration with the Civil Aviation Authority (CAA) endorses the FAA policy and recommends the use of the SGHAT to carry out assessments.

The SGHAT visualises the ocular impact of glare with the Glare Hazard Plot for each of the SPVs group considered (see for example Figure 21). This chart displays the ocular impact as a function of glare subtended source angle (size of glare source divided by distance) and retinal irradiance (the solar flux entering the eye and reaching the retina). Each minute of glare is displayed on the chart as a small circle in its respective hazard zone. For convenience, a reference point is provided which illustrates the hazard from viewing the sun without filtering, i.e. staring at the sun. Each plot includes predicted glare for one SPV array and one receptor. According to the diagram, the ocular impact of solar glare is quantified into three categories:

- Green – ‘low potential’ to cause after-image (flash blindness).

For a given retinal irradiance, smaller source angles yield smaller after-images, and the potential impact is lower.

- Yellow – ‘potential’ to cause temporary after-image (flash blindness).

Retinal irradiance is sufficiently large to cause temporary after image or ‘flash blindness’, like the effect after viewing a camera flash in a dim room. The size and impact of the afterimage in the field of view depends on the size of the subtended source angle. For a given retinal irradiance, smaller source angles yield smaller after-images, and the potential impact is lower.

- Red - potential to cause retinal burn (permanent eye damage).

Retinal irradiance is sufficiently large, permanent eye damage and retinal burn may occur.

These categories assume a typical blink response in the observer. Note that retinal burn is typically not possible for SPV glare since SPV modules do not focus reflected sunlight.

The FAA guidance, adopted by CAA, suggests that if the proposed installation meets the following criteria the SPV array will not have a significant impact on the operational flight safety of aircraft¹:

- No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and
- No potential for glare or “‘low potential for after-image” (shown in green in Figure 21) along the final approach path for any existing landing threshold or future landing thresholds (including any

¹ FAA, “Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports”, www.gpo.gov, 23rd October 2013

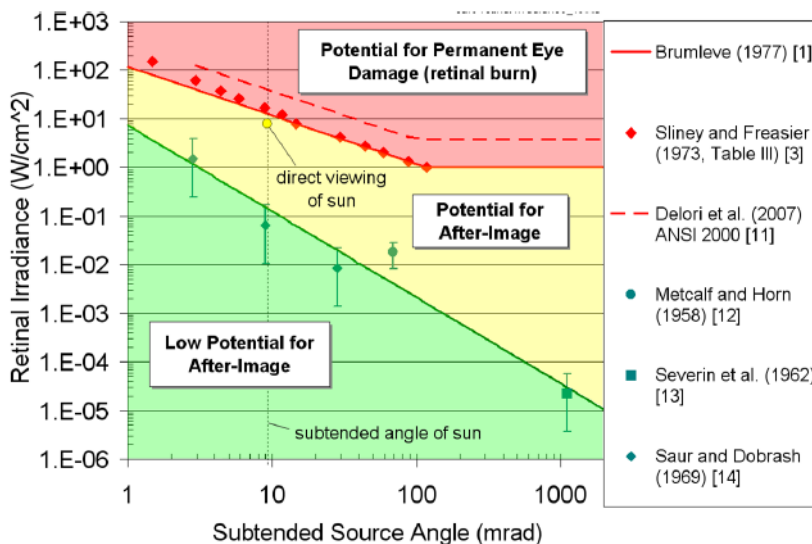
planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath.

The SGHAT provides other visual representations of the glare potential:

- Annual predicted glare occurrence.
- A graph illustrating the time of year and time of day glare may occur.
- Daily duration of glare.
- A graph illustrating number of minutes of glare expected on each day of the year.
- Approximate flight path location where glare is visible (for final approaches only)
- A graph illustrating this distance from the threshold that glare is predicted for each day of the year.
- Glare reflections on SPV footprint (fixed observation points only).
- A plan showing the area of the SPV array from which the glare originates.

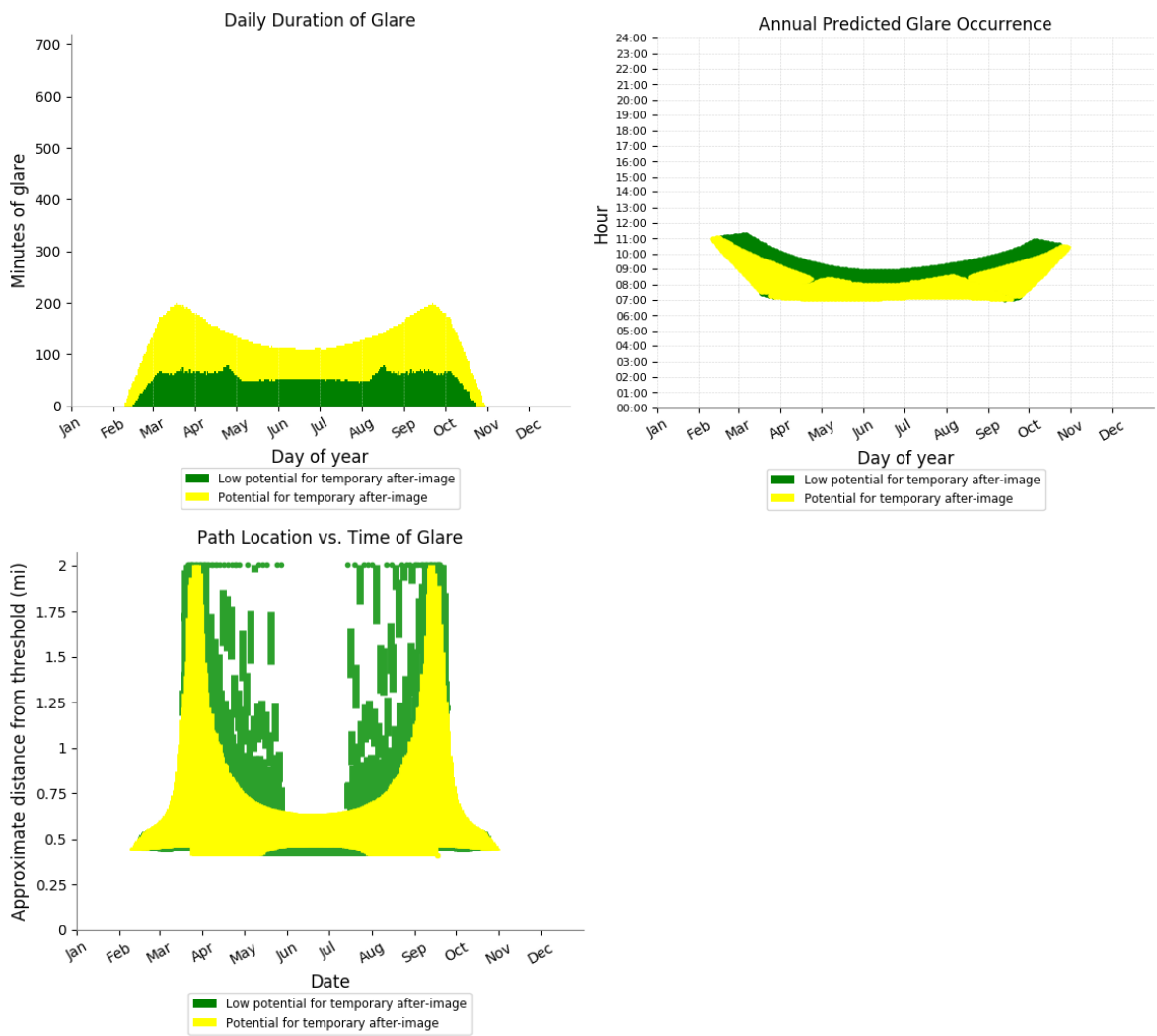
All graphs are colour coded to represent to quantification category of the glare.

Figure 21 – Typical glare hazard plot – Forge Solar GlareGauge SGHAT



Additional graphs are provided by the software for each flight path which identify the number of minutes that a glare experience may occur per year, a chart indicating the time of year of the occurrence and a chart of the flight path indicating the risk of after image, refer to Figure 22.

Figure 22 Supplementary visual representations.



3.2 SGHAT Results

The proposed SPV arrays on each building have been divided into parts based on their orientations and tilt. Each part has been assigned a reference number as shown in Figure 23 - Figure 25. The SGHAT tool analysis each SPV part separately to ensure a granular and accurate assessment of potential glare contributions.

Figure 23 Reference number for proposed SPV arrays (Patrick Cryne Building)

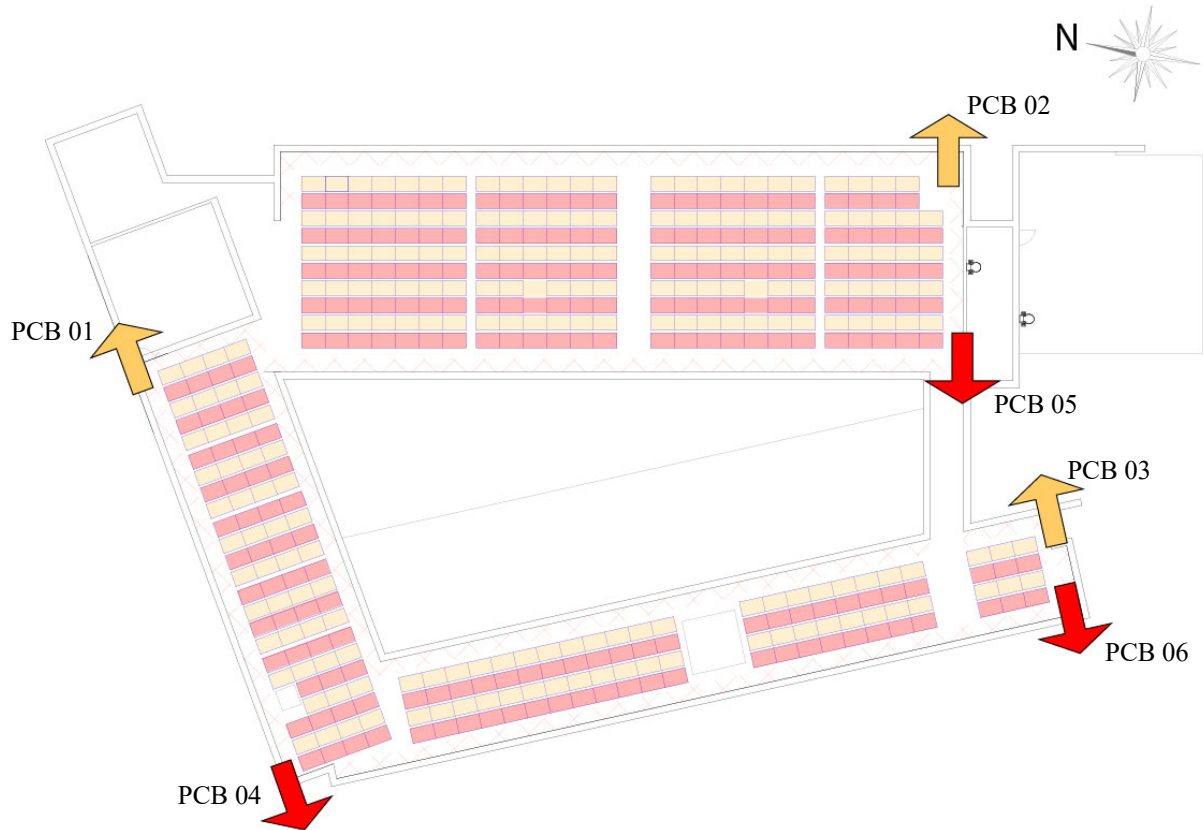


Figure 24 Reference number for proposed SPV arrays (Clinical Science Building)

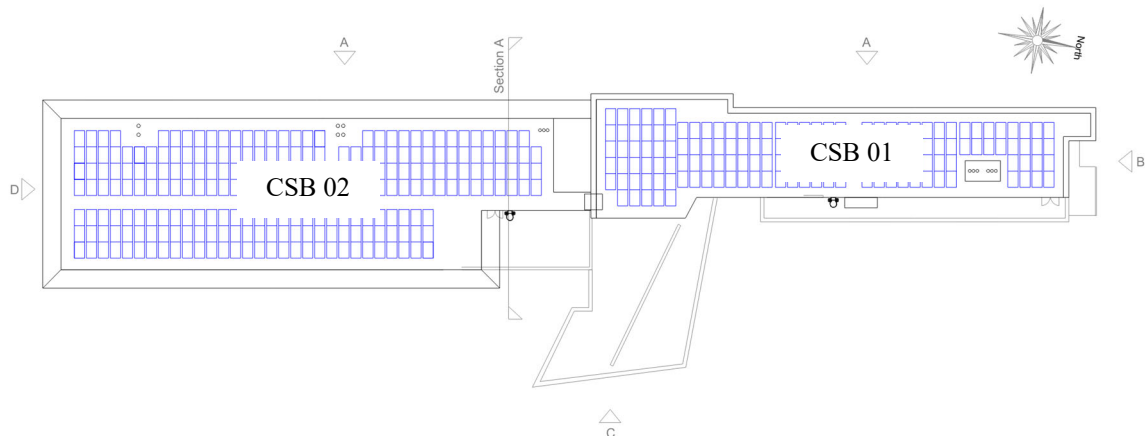
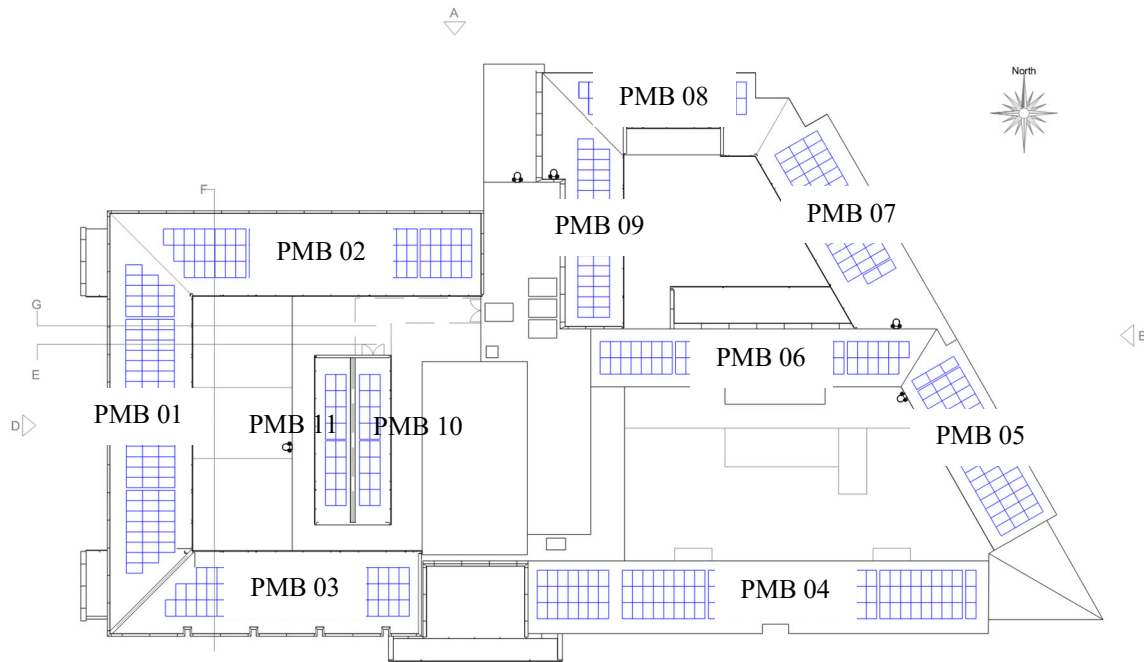


Figure 25 Reference number for proposed SPV arrays (Peter Mount Building)



To ensure comprehensive coverage of the operational area, eight representative flight paths (A-H) within the Normal Approach Profile have been selected (Figure 26):

- Flight Path A, F, G, H: along the periphery of the Normal Approach Profile area
- Flight Path B: aligned to the due-west direction
- Flight Path D: aligned to the due-south direction
- Flight Path E: passing through the central area of the proposed SPV arrays.

SGHAT analysis has been undertaken on the following receptors:

- Risk of glint/glare/reflection on departures and final approach for Flight Paths A-H

The outcomes are summarised in Table 1.

Figure 26 Selected flight paths

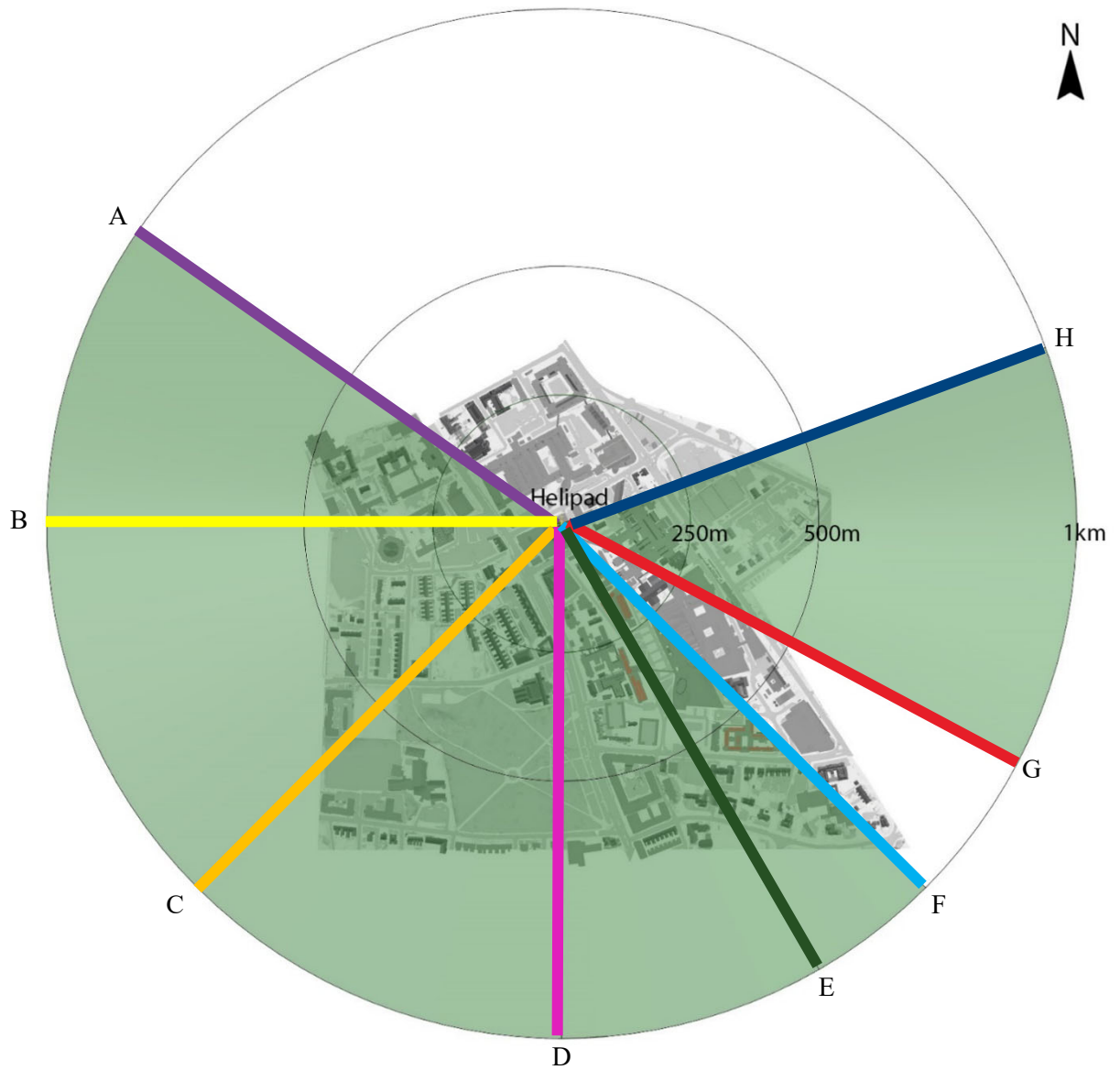


Table 1: SGHAT results summary

SPV reference	Tilt	Orientation (clockwise from due	"Green" Glare	"Yellow" Glare
PCB01	10	46	✓	✗
PCB02	10	66	✓	✗
PCB03	10	53	✓	✗
PCB04	10	226	✓	✗
PCB05	10	246	✓	✓
PCB06	10	233	✓	✗
CSB01	4	68	✓	✗
CSB02	4	248	✓	✗
PMB01	4	90	✓	✗
PMB02	4	180	✓	✗
PMB03	4	0	✓	✗
PMB04	4	0	✓	✗
PMB05	4	241	✓	✗
PMB06	4	180	✓	✗
PMB07	4	241	✓	✗
PMB08	4	180	✓	✗
PMB09	4	90	✓	✗
PMB10	4	90	✓	✗
PMB11	4	270	✓	✗

Table 1 indicates there is a low potential for temporary after-image to helicopter operations on all eight flight paths (A-H) tested for the PCB01-04 and PCB06 SPV arrays, as well as the SPV arrays located on the roofs of the Clinical Science Building and Peter Mount Building, during both final approach and take-off phases.

The results further indicate that there is a 'potential' for after-image associated with the PCB05 SPV array for helicopter operations on certain flight paths. Table 2 summarized the duration of predicted green and yellow glare for each flight path from the PCB05 SPV array.

Table 2 Duration of predicted green and yellow glare for each flight path from the PCB05 SPV array

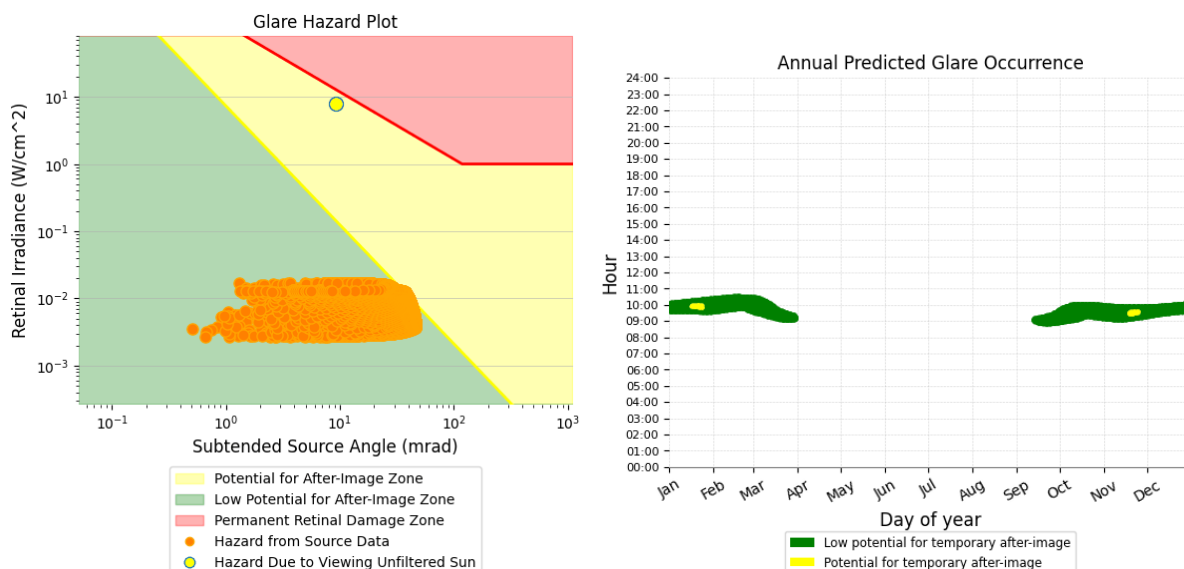
Flight Path	Green glare (min)	Yellow glare (min)
Flight path A	8753	75
Flight path B	10208	24
Flight path C	982	0
Flight path D	22986	349
Flight path E	10344	278
Flight path F	31068	352
Flight path G	28391	321
Flight path H	9022	0

3.2.1 PCB05

Figure 27 indicates the findings of the PCB05 array using the glare hazard plot and annual predicted glare occurrence. The yellow section of the glare occurrence chart indicates 'potential' for after image for 1399 minutes per year compared to 121,754 minutes of 'low potential' after image (green) per year.

The SPV orientation of resulting in the yellow/low potential outcome is only attributable to the west facing SPV arrays in this location on the Patric Cryne Building.

Figure 27 Glare hazard plot and annual predicted glare occurrence for Flight Path A (refer to Appendix A for B-H)



Detailed results and glare hazard plots for each flight path and SPV array are provided in Appendix A.

4. Observations, Considerations and Mitigation

4.1 Other Reflecting Bodies

While the results of the analysis indicate that reflected sunlight from the proposed SPV array has the potential to enter the cockpit, the potential impact should be considered in the context of other natural and manmade reflective surfaces in and around this city location such as:

- Inclined and horizontal glazing to the terminal building.
- Large areas of vehicle parking.
- Roof glazing.
- Domestic SPV installations.
- Bodies of water or water build up following heavy rainfall.

4.2 Impact of Weather

Assessments are undertaken assuming a clear cloudless sky. The potential for glint and/or glare from reflected sunlight will not exist where cloud, rain or other weather event obscures the sun from the panels.

- Direct irradiance is the part of the solar irradiance that directly reaches a surface.
- Diffuse irradiance is the part that is scattered by the atmosphere.
- Global irradiance is the sum of both diffuse and direct components reaching the same surface.

The data presented in Figure 28 shows the direct irradiance though out the year for Aughton, Lancashire (the closest weatherdata set to Manchester). Review of this direct irradiance monthly average data reveals there are points of the year, when the proportion/probability of direct sunlight is much higher.

Figure 28 Daily Direct Irradiance (Weather data for Aughton, Lancs)

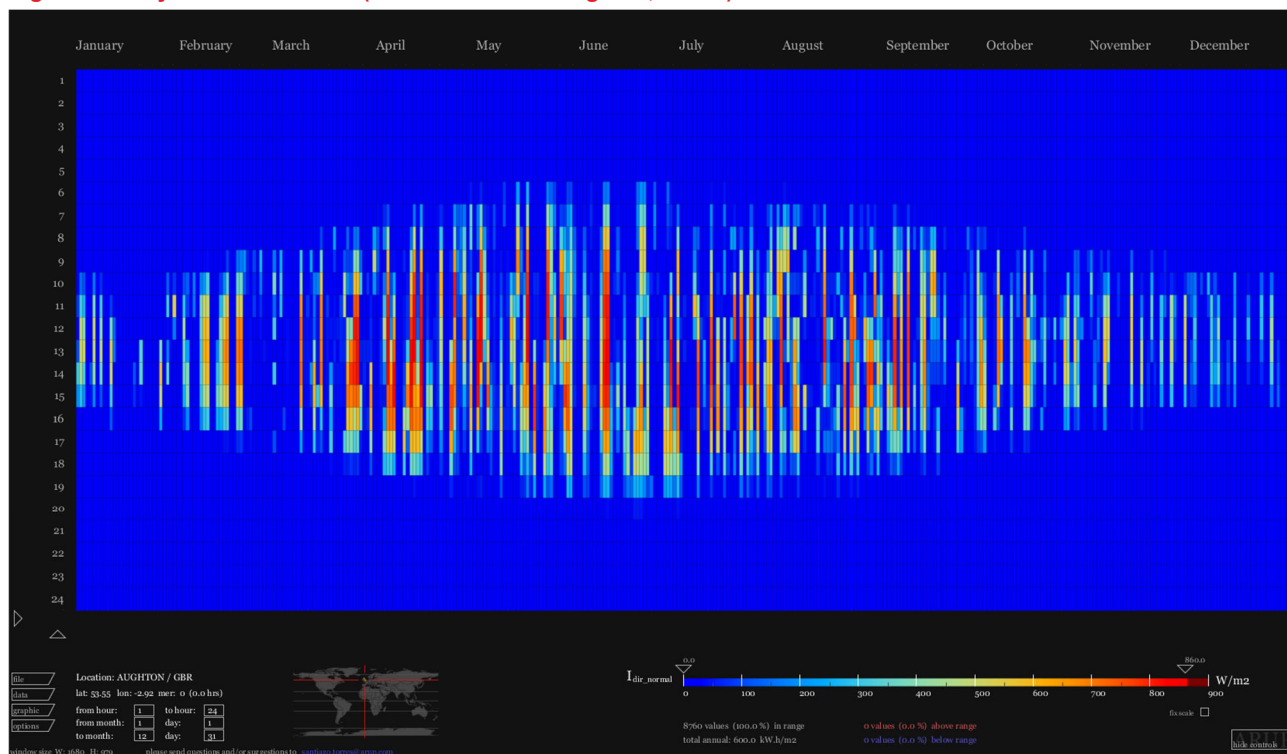


Figure 29 Daily Cloud Cover (Weather data for Aughton, Lancs)



Cloud cover is illustrated in Figure 29 and is measured in Oktas. This provides a quantitative scale of how much cloud cover is visible at a point in time. It does not take into consideration the density or how dark the clouds are but will influence the exposure due to the amount of direct/diffuse light there is in the sky.

If a cloud cover has a value of 6-8 Oktas (3/4 to full cloud cover) it could be considered likely to provide an approximation of an overcast sky. While this is likely to be the sky condition for part of the year, it cannot be considered to be the predominant condition.

4.3 Coating

Different coatings on the SPV array will have a significant impact on the resulting reflections. Where a smooth glass with anti-reflective coating (ARC) may cause a small amount of glint and glare, a deeply textured glass coating is able to spread it out over a wider area and make the effect less intense. However, as deeply textured increases the scattering of reflected sunlight, the potential for glare is also spread over a wider area.

5. Conclusion

Arup has undertaken a Glint and Glare assessment in line with current CAA/FAA guidance to assess any potential impact of the proposed solar photovoltaic (SPV) installations at the Manchester Royal Infirmary (MRI) located to the south-east of the NHS helipad.

The assessment has assumed the SPV array has covered the whole of identified roof areas and makes no allowance for gaps and spaces for other rooftop mounted services therefore representing a worst-case scenario.

A geometric assessment has been undertaken to establish when and where reflected sunlight from the SPV panels has the potential to enter the cockpit of a helicopter. Geometric modelling does not quantify the risk of glint and and/or glare. The geometric modelling indicates that reflected sunlight from the proposed SPV installations will be visible from departure and take-off locations.

Based on the findings of the geometric assessment, a Stage 2 assessment has been undertaken using the Solar Glare Hazard Analysis Tool (SGHAT) to quantitatively assess the potential impact of reflected sunlight on helicopter operations during both final approach and departure. The SGHAT results indicate:

- a low potential for temporary after-image effects for the majority of assessed SPV arrays
- a potential for temporary after-image effects for an annual total of 1399 minutes at approximately 10am in January and November, resultant from only from the west facing arrays of PCB05 SPV array. This is based on a clear sky scenario; however it is noted there is also a low probability of direct sunlight and high probability of cloud cover at the same time.

Based on the findings of the assessment no mitigation measures are deemed necessary to the proposed solar photovoltaic (SPV) panels on the roof of the Clinical Science Building and Peter Mount Building in accordance with the latest CAA and FAA guidance.

Mitigation of the Patrick Cryne Building may be considered necessary for the west facing SPVs, in particular PCB05. To mitigate the reflections, the SPVs could be orientated towards the east in a 'sawtooth' type array.

It must be noted that this assessment has been taken based on the submitted design information by AFL Architects (January 2026). Any deviations from the specification in the final design may affect the validity of the results and require a re-assessment of the glint and glare effects.

Appendix A