Luton Rising

Our airport.
Our community.
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August 2023

London Luton Airport Expansion

Planning Inspectorate Scheme Ref: TR020001

Volume 5 Environmental Statement and Related Documents

5.13 Glint and Glare Assessment

Application Document Ref: TR020001/APP/5.13

APFP Regulation: 5(2)(a)

The Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

London Luton Airport Expansion Development Consent Order 202x

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5.13 GLINT AND GLARE ASSESSMENT

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1 EXECUTIVE SUMMARY

1.1.1 Current generation solar technology is much improved in function and materiality over earlier incarnations of panels and arrays. The current materials and finishes used in the production of solar panels has significantly reduced the potential for reflection, although it hasn’t been able to be removed entirely.

1.1.2 Studies and guidance produced by the Federal Aviation Authority (FAA), who have provided the most widely used regulations and guidance in relation to glare and aviation, consider that the influence of new solar panel technology may in some cases, such as considering effects on aircraft approach, have a similar glint and glare effect to that of windshields on cars in a car park, glass façade buildings, or light on water, and so the potential effects of glint and glare are largely in keeping with typical urban developments or sufficiently large bodies of water.

1.1.3 There is a greater potential for glint and glare effects to occur to Air Traffic Control Towers (ATCT). While the FAA has revised their stance on flight path for most scenarios, the likelihood of glare to affect ATCTs is still a concern. This is largely related to the fixed nature of the cab location and visual clarity requirements to remain consistent to support the safety and movement of aircraft and vehicles around the airport, as well as be able to visually monitor the airport airspace.

1.1.4 Two contemporaneously adopted solar panel installation configurations have been assessed for the 12 proposed installation locations identified in the outline proposals:

a. Solar panels southwardly angled in rows sufficiently separated to prevent adjacent panels’ shading
b. Solar panels mounted in east west angled concertinaed rows adjacent to each

1.1.5 Given the arrangements of Luton Airport and the maximum parameters used in assessment that are aligned with the outline design of the proposals, the potential for glare has been identified for both a southward facing or east-west orientated installation. As the designs and the site proposals are refined, a more detailed analysis can be made regarding the potential for reflected solar glare impacts to further inform the detailed design development and planning process.

1.1.6 The assessment undertaken to date is based on the outline design and possible mounting locations and indicates that all buildings and carparks identified could potentially support solar panel arrays and be in keeping with good practice. The optimal placement and configuration would need to be confirmed through a calculated analysis based on the detailed design of the proposals, required power generation and solar panel specification.

2 INTRODUCTION

2.1.1 Luton Rising (a trading name of London Luton Airport Limited, hereafter referred to as the Applicant) is a business and social enterprise owned by a sole shareholder, Luton Borough Council, for community benefit.

2.1.2 The Applicant is seeking to make best use of the existing runway at London Luton Airport (the airport) by constructing a new terminal and associated infrastructure to increase the number of flights and passengers the airport can handle (the Proposed Development). The current permitted capacity of the airport is 18 million passengers per annum (mppa), and the Proposed Development seeks to increase this to 32 mppa by the mid-2040s.

2.1.3 As part of this Proposed Development the Applicant is looking to provide up to 28MW of onsite solar energy generation using photovoltaic panels (PV), or solar panels, attached to new buildings and surface carpark structures.

2.1.4 Solar panels are generally designed to absorb as much light as possible for optimum efficacy. However, there is potential for them to create solar glare by reflecting the sun's image in sensitive viewing directions.

2.1.5 The potential for problematic reflected solar glare to occur from solar panels depends on their materiality, placement and orientation relative to sensitive receptors that are likely to be affected by them.

2.1.6 The occurrence of reflected solar glare can cause unacceptable visual impacts on sensitive receptors that are ground based or airborne in the form of visual discomfort, distraction or impairment.

2.1.7 This report is intended to provide a preliminary assessment for the potential of reflected solar glare, also referred to as 'glint and glare', to primary sensitive receptors, both ground based and airborne from the Applicant's solar energy generation proposals.

2.1.8 It has been provided at the request of the Examining Authority (ExA) which issued an additional Procedural Decision on 13 June 2023 requesting that an assessment should be provided as part of the application, rather than at detailed design stage, to allow the assessment of any effects to be subject to examination.

2.1.9 Luton Rising confirmed in its response to the Procedural Decision on 27 June 2023 that an assessment would be provided by the ExA's requested date of 9 August 2023. This would be a desk top assessment that would identify locations within the Proposed Development suitable for hosting solar panels and provide an overview of predicted performance. Based on the outcome of this initial assessment, further modelling/analysis may be required for some proposed solar panel locations within the development.

2.2 Scope of Assessment

2.2.1 The focus of the study is the potential impacts of reflected glare from solar panels in different locations within the site and the potential for this to affect airport operations and / or other nearby sensitive receptors. The risk of other potential sources of lighting glare associated with the Proposed Development, such as from night-time lighting, are outside the scope of works.

2.2.2 This is a preliminary study and does not provide a calculated assessment of potential duration or intensity of reflected solar glare. A further assessment would be carried out at detailed design stage.

2.2.3 Local sensitive receptors that are considered as part of the study include the following:

a. Air traffic using the runway
b. Airport operations buildings
c. Road traffic using adjacent major routes

2.2.4 The areas solar panels are proposed to be placed to provide the target 28MW capacity include:

a. Multistorey Car Park Buildings
b. Surface and Deck Car Parks
c. Terminal Building

2.3 Documents Referenced

Standards and Guidance

2.3.1 Federal Aviation Administration (FAA) Rules and Regulations 25801, 2021, Federal Register Vol. 86, No. 89. (current)

2.3.2 Federal Aviation Administration Rules and Regulations 63276, 2013, Federal Register Vol. 78, No. 205. (for reference of previous requirements)

2.3.3 Federal Aviation Administration Technical Guidance for Evaluating Selected Solar Technologies on Airports, Version 1.1, 2018

2.3.4 Federal Aviation Administration DOT/FAA/AM-15/12, Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach, 2015

Drawings

2.3.5 The following drawings within **4.02 Scheme Layout Plans [AS-010]** are used for assessment:

a. Indicative Scheme Layout Plan Future Baseline - LLADCO-3C-CAP-WHS-GEN-DR-AR-1
b. Indicative Scheme Layout Plan Assessment Phase 2b - LLADCO-3C-CAP-WHS-GEN-DR-AR-1

2.4 Maps

2.4.1 The following navigation charts are referenced within the assessment and are available from www.aurora.nats.co.uk:

a. Existing Aerodrome Chart - AD 2-EGGW-2-1

b. Standard Departure Chart - AD 2-EGGW-6-1
c. Standard Arrival Chart - AD 2-EGGW-7-3
d. Standard Minimum Altitude Chart - AD 2-EGGW-5-1

Documents

2.4.2 The following application documents are referenced within the assessment:

a. Draft Development Consent Order **[AS-005]**
b. Environmental Statement Appendix 4.3 Energy Statement **[APP-050]**
c. Scheme Layout Plans **[AS-010]**

3 METHODOLOGY

3.1 Approach

3.1.1 A high-level desktop-based assessment approach utilising angular qualitative assessment parameters in combination with practical installation observations has been used to assess the potential viability of the solar energy generation proposals. The viability of the proposals is only assessed with regard to their potential to create problematic reflected solar glare impacts on sensitive receptors and not the general solar power generating capacity of the proposals.

3.1.2 Observations on potential locations across the development site are provided in connection with assessing the proposed locations for solar panels.

3.1.3 The following assessment approach flow is adopted:

a. Identify problematic glare effects and parameters contributing to their potential occurrence;
b. Identify baseline and existing context conditions relevant to the assessment;
c. Identify phased development layouts, equipment types and installations configurations;
d. Identify key sensitive receptors;
e. Review the angular location of proposed equipment, its installation configuration, equipment characteristics and environmental considerations;
f. Assess the potential of the proposals to create glint and glare impacts to identified sensitive receptors; and
g. Provide recommendations for next steps.

3.2 Effects

3.2.1 Glare effects can be caused by a significant contrast between a light source and darker surround or lower background illuminance over a period of time and can occur from both artificial and natural light sources. Solar glare involves the effect created by reflected sunlight.

3.2.2 In either case, depending on the intensity and length of time involved, the effect can be considered as glint or as glare as referenced within FAA 'Technical Guidance for Evaluating Selected Solar Technologies on Airports'.

a. Glint: “A momentary flash of bright light”
b. Glare: “A continuous source of bright light”

3.2.3 The effects of glare can be organized into three primary categories: permanent eye damage, potential for after-image, and low potential for after-image. It is worth noting that estimating visual comfort and performance is complex, given their subjective nature and the variation in response between individuals. In scenarios there is potential for glint or glare that occur with high enough irradiance levels, permanent eye damage, specifically retinal burn, may occur. However, retinal burn is not a risk from photovoltaic (PV) glare as the reflected light is not focused. Yellow glare describes a region in the glare hazard plot used by the FAA that represents high retinal irradiance levels, which could induce temporary flash blindness, a condition stemming from the bleaching of visual pigments in the retina. A detailed overview of the types of potential glare impacts from the proposed solar panels is set out in Table 3-1.

Table 3-1 - Degree of Glare Impact

Degree of Glare Impact	Definition	Colour code for glare impact (as per FAA)	Mitigation Status	Remarks
No impact	Reflection from solar PV module does not occur at any instant in time	Not Applicable	No mitigation is required	Nil
Low	Solar reflection occurs at some point in time with lesser strength	Green Glare	No mitigation is required	Nil
Moderate	PV module reflection happens at an instant with a slight disturbance to vision	Green Glare	Mitigation is needed in case of some receptors such as ATC towers	Present in selected areas
High	A significant level of solar reflection happens and affects visibility from sensitive receptors	Yellow glare	Mitigation is mandatory for solar project approval	Seen in the selected area
Extreme	A severe level of reflection causes immediate, irreversible damage to eyes	Red Glare	Mitigation is mandatory and urgent for all circumstances	Extreme caution in all areas

3.2.4 There are a few factors which can influence how likely an occurrence of glare is to result and resulting in a potential hazard. These are industry standard factors and include:

a. Material reflectivity of a surface;
b. Angle of incidence;
c. The location of the installation;
d. The type of receptor considered and its distance from the source or reflective surface; and
e. Intensity of the light source.

3.3 Materials

3.3.1 The type of material that a solar panel is constructed from will have a large influence over how reflective it will be.

3.3.2 A smooth surface will result in a reflection that is similar to the angle of the light source. A diffuse surface will scatter the direction of incoming light so that reflected light is less intense.

3.3.3 It is noted that a diffuse surface may have a longer lasting effect than a specular surface, however in many cases it may be experienced as more of a glowing surface than contributing to flashes of light.

3.3.4 A bare silicon cell can be 30 – 36% reflective and lost light is lost energy, so the majority of solar panels will introduce new materials either through a coating or textured glass, or both, to reduce the amount of reflection and increase light absorption into cells. Older panels are likely to have higher reflectivity, however new generation panels would typically be 2 – 3% which has been compared to the effect of light on water.

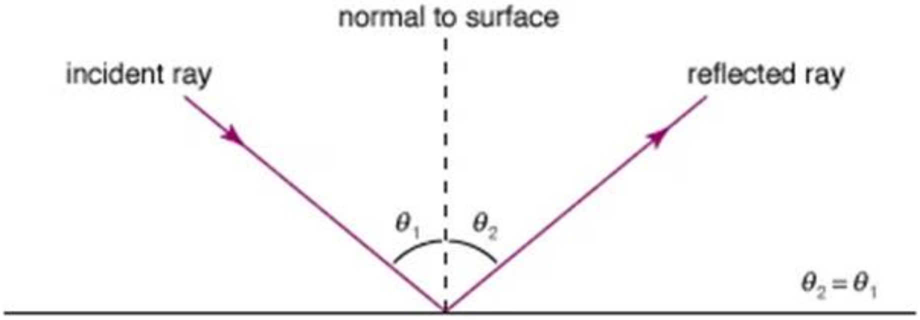
3.3.5 The use of anti-reflective coatings can be used on the cell or to the cover glass. This can reduce the potential reflectivity of the average solar panels to anywhere from 1 – 8%. It should be noted that coatings on solar panels would need to be carefully maintained as the life can be reduced due to corrosion and cleaning.

3.3.6 A textured surface could also be used in conjunction with the solar panel which could help to create a more diffuse surface and possibly have a solar panel with a longer life.

3.4 Angle of Incidence

3.4.1 The angle of incidence is the angle between a ray incident on a surface and the line perpendicular to the surface at the point of incidence, called the normal. Figure 3-1 shows this principle.

Figure 3-1 Angle of Incidence (Source: ttps://www.britannica.com/science/light/Reflection-and-refraction#/media/1/340440/91333)



3.4.2 This angle changes as the sun moves across the sky during the day and time of year.

3.4.3 The incident angle of sunlight is typically the smallest when the sun is directly overhead, and it increases as the sun moves towards the horizon during the early morning and late afternoon periods..

3.4.4 Note that where solar panels are mounted to a tilted or sloping roof that potential incidents of glare will be biased toward the direction of tilt and contribute to less potential glare in the opposite direction.

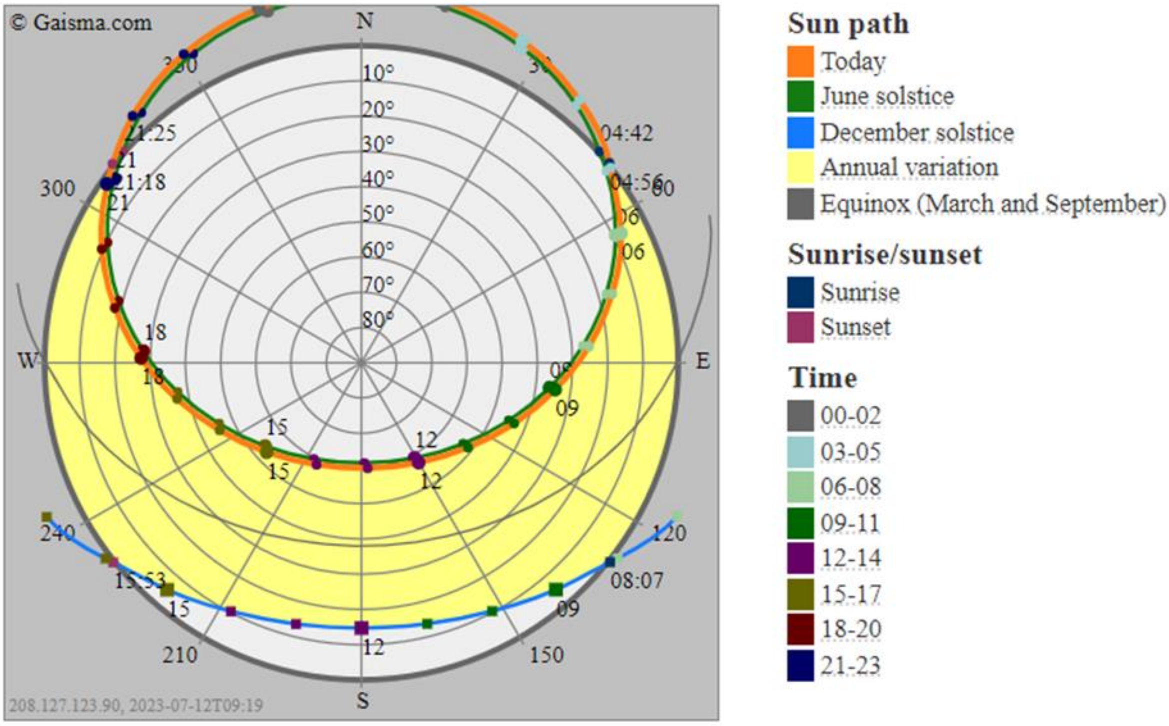
3.5 Location of the Installation

3.5.1 Luton is in the northern hemisphere which means the sunpath is generally from a southwardly direction for the majority of the year. Due to the northerly latitude, there is a significant sunpath shift.

3.5.2 The potential for glare changes throughout the day and typically throughout the year in most locations. Largely unobstructed solar panels in the northern hemisphere are typically tilted / orientated south toward the equator and is assumed in this assessment. Flat rather than tilted arrangements can be adopted where southerly shading is a consideration.

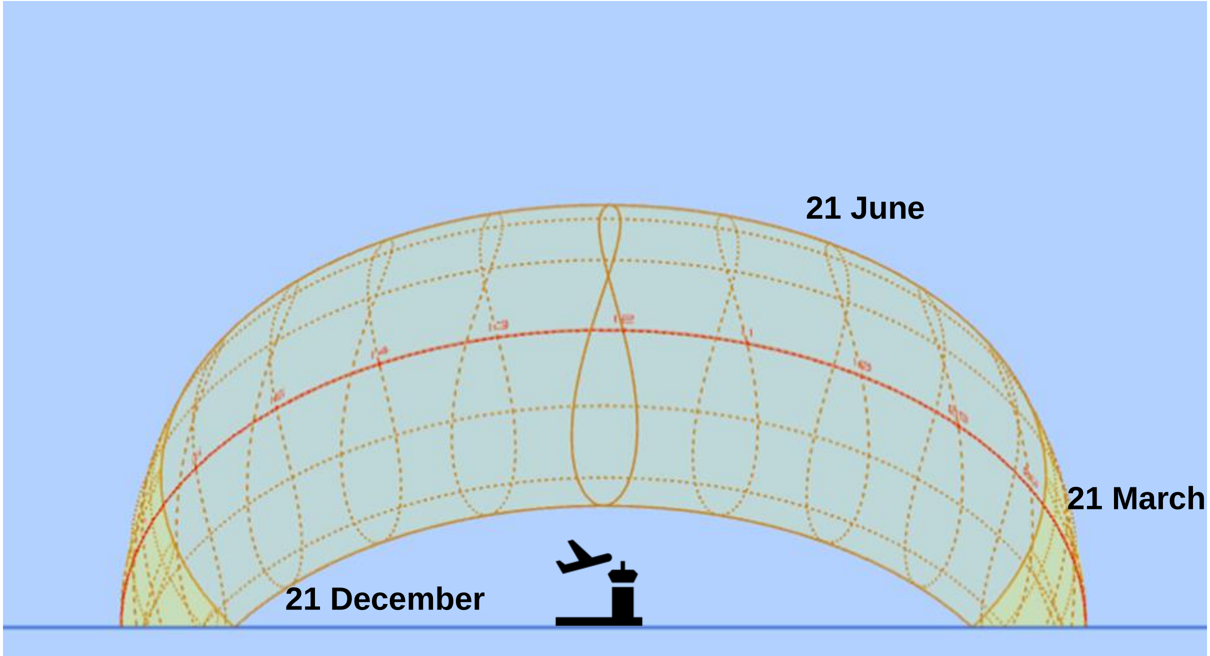
3.5.3 Figure 3-2 presents an overview of the sunpath throughout the year showing sunpath shift and corresponding change in angle of light that could reach the solar panels. The higher the sun angle shines from, the steeper the angle of incidence and the corresponding area of reflection is more contained. The lower the sun angle is, the more likely a reflection is to occur within a receptors 'field of view', although this will depend on the location of the receptor, location and orientation of the panel(s) and degree of sunlight available.

Figure 3-2 Luton Sunpath Map (Source: https://www.gaisma.com/en/location/luton.html)



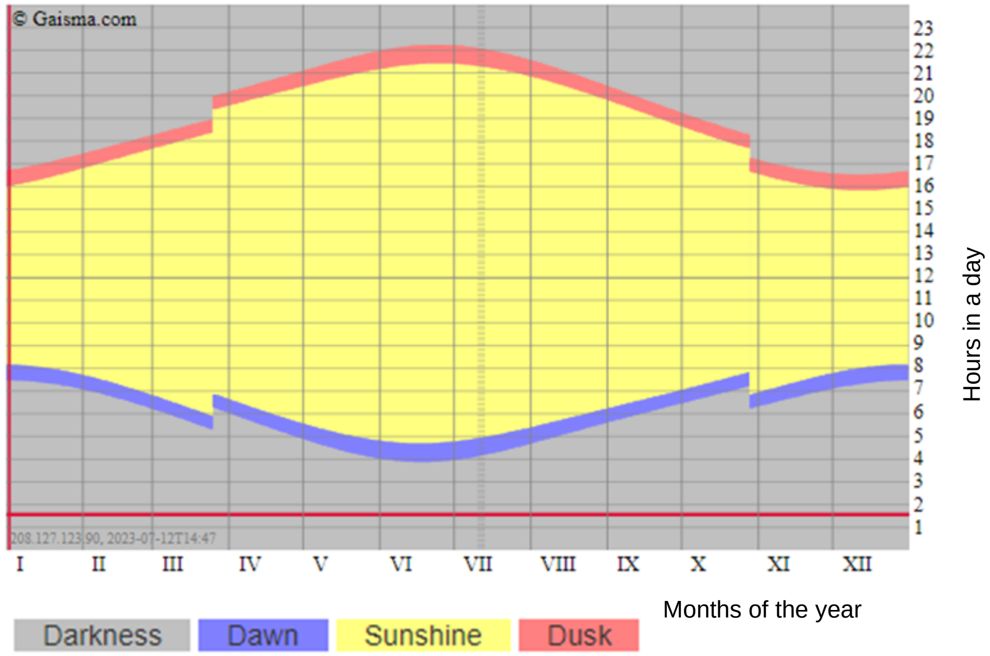
3.5.4 The sunpath varies significantly throughout the year with the azimuth varying by approximately 47 degrees at most between June and December, so solar conditions will be varied through seasonal orientation. The azimuth is an angular measurement from an observation point to a point of interest that is projected perpendicularly onto a reference plane in a spherical environment. Figure 3-3 provides an alternate 3D view of the sunpath where the red line indicates mid-day on the equinox, 21 March. This gives a better visual overview than the 2D view of where the sun might be in the sky for particular times of day for solar conditions that have the highest sun angle (21 June, Summer Solstice), lowest sun angle (21 December, Winter Solstice), and the Mid-year solar condition of 21 March as noted above, in relation to objects.

Figure 3-3 Luton 3D Sunpath Diagram (Source: http://andrewmarsh.com/apps/staging/sunpath3d.html)



3.5.5 Figure 3-4 provides a graphical overview of daylight hours and shows the dawn and dusk period. During the dawn and dusk period, sun angles can be quite low compared to typical daytime solar conditions and there is potential for an increased angle of incidence to occur. In the UK, period shifts annually, but still provides a fairly consistent length of time at the start and end of day where low angles could occur.

Figure 3-4 Luton Daylight Hours (Source: https://www.gaisma.com/en/location/luton.html)



3.6 Type of Receptors

3.6.1 The types of receptors considered for assessment are those which could be affected by a visual hazard and result in impacts. This includes pilots in aircraft, persons in the air traffic control tower (ATCT), and potentially vehicles on existing or new roads constructed as part of the Proposed Development.

3.6.2 Aircraft are considered with regard to the direction of view for the pilot chiefly for aircraft on approach and landing. Departing aircraft and those on arrivals (but not on approach) are also considered. It is noted that while moving on the ground, a typical commercial passenger aircraft which operate at Luton Airport are B737 and A320 which have a pilots eye height of approximately 4.5m.

3.6.3 The ATCT allows for a 360-degree view so that controllers can have visual observation of the immediate airport environment which allows them to coordinate take off, landing and ground traffic. The viewing platform / cab is approximately 30+m above ground level.

3.6.4 Vehicles on local roads are considered where they would be on the approach to conflict areas in a committed direction of travel, such as junctions or pedestrian crossings.

4 BASELINE AND PROPOSED DEVELOPMENT OVERVIEW

4.1 Site context

4.1.1 The Proposed Development is located adjacent to the existing London Luton Airport buildings and airfield facilities. Existing urban development borders the site to the north, existing industrial development borders the site to the west and open green space borders the site to the south and east. The development site itself is a mixture of green and brownfield space within line-of-sight view of the existing ATCT.

4.1.2 The existing runway is orientated north-east to south-west, just off from true east-west (bearing 74.4º to 254.4º) refer to Figure 4-1 and Figure 4-2.

4.1.3 The existing buildings and facilities associated with the airport are located to the north of the runway as shown on Figure 4-1 and Figure 4-2.

4.1.4 New buildings and facilities associated with the proposed development will be located to the north and west of the runway as shown on Figure 4-3.

4.1.5 There are no existing significant reflective surfaces in the direct line of sight from the ATCT and the airfield facilities.

Figure 4-1 Existing Site Context Plan **4.02 Scheme Layout Plans [AS-010]**

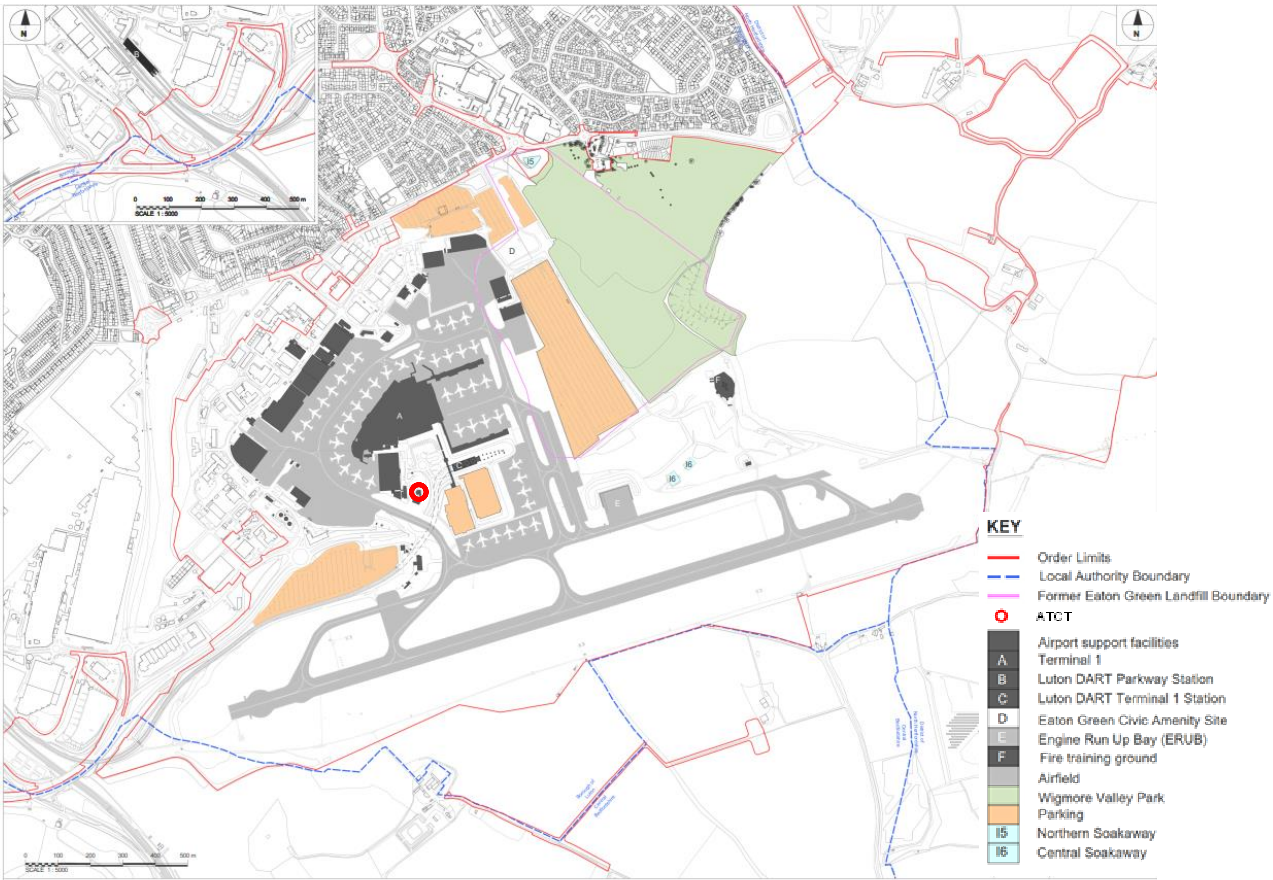


Figure 4-2 Existing Site Context Aerial Photograph (Source: www.google.com/maps)

4.1.6 The airport has two directions of operation, depending on the wind direction, as aircraft are required to take off and land into the wind for safety reasons. These are known as easterly operations and westerly operations.

4.1.7 During westerly operations, aircraft will depart towards the west. The prevailing wind direction in Luton is from the west. On average the wind is from this direction for 70% of the time. During easterly operations aircraft will depart to the east, which occurs on average 30% of the time. As both take-off and landing paths can be in two directions the potential for reflected solar glare to aircraft requires assessment in both.

4.1.8 The split in operating direction varies from year to year and month to month. The amount of time that the runway operates in one direction depends on the weather and could change daily but it is not uncommon to be operating in one direction for several weeks or months.

4.2 Proposed Development

4.2.1 The Proposed Development will sit to the north and west of the existing runway. The existing ATCT will be retained with some Proposed Development located between the ATCT, the runway, aircraft taxiways and stand locations.

4.2.2 New proposed facilities including parking and the proposed terminal are shown on drawing **4.02 Scheme Layout Plans [AS-010]** replica of which is shown on Figure 4-3.

4.2.3 Figure 4-4 shows the assessment over time for the deployment of the solar panels over individual carparks and the proposed terminal roof.

Figure 4-3 Proposed Site Layout (replica of 4.02 Scheme Layout Plans [AS-010])

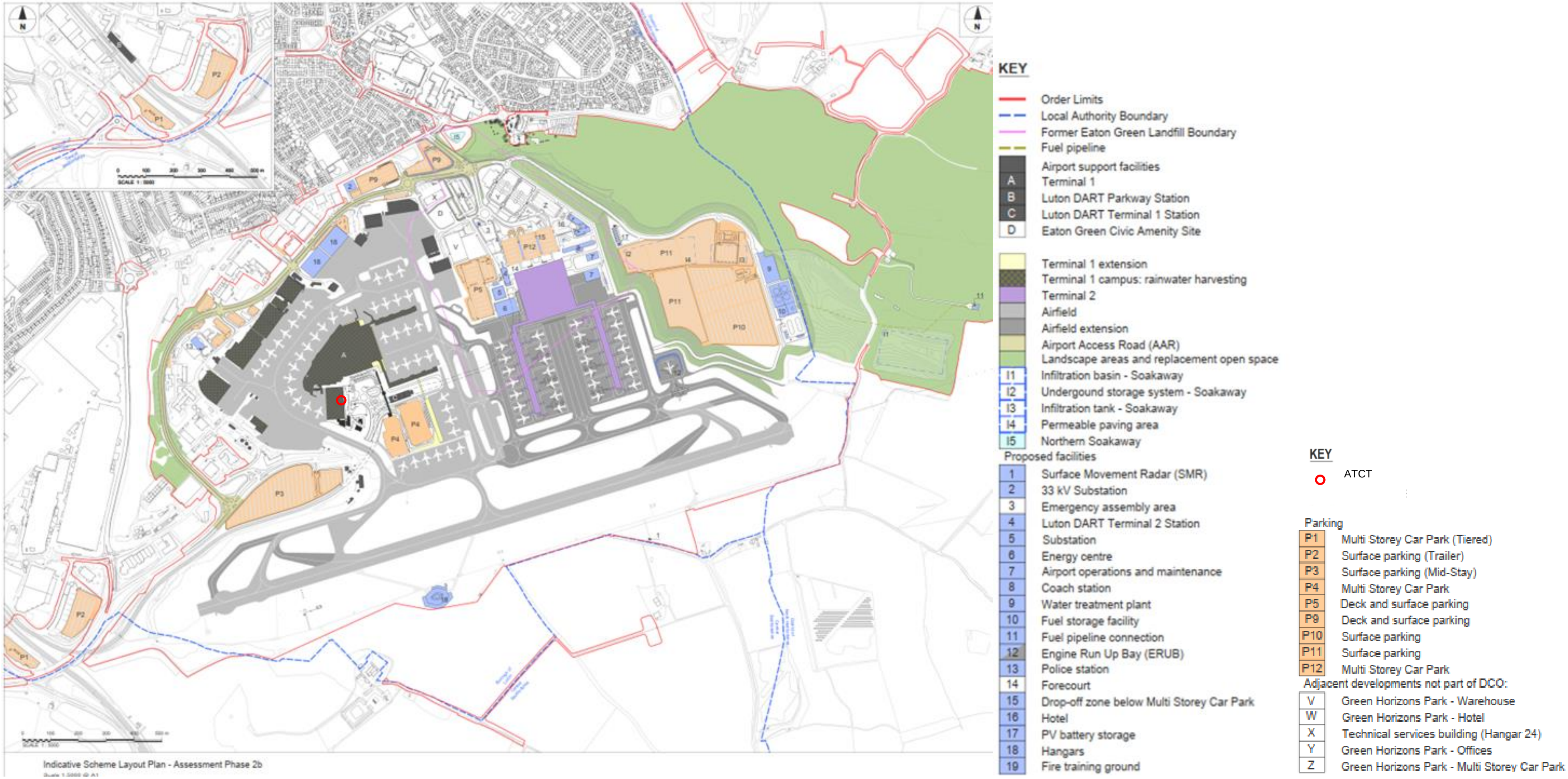
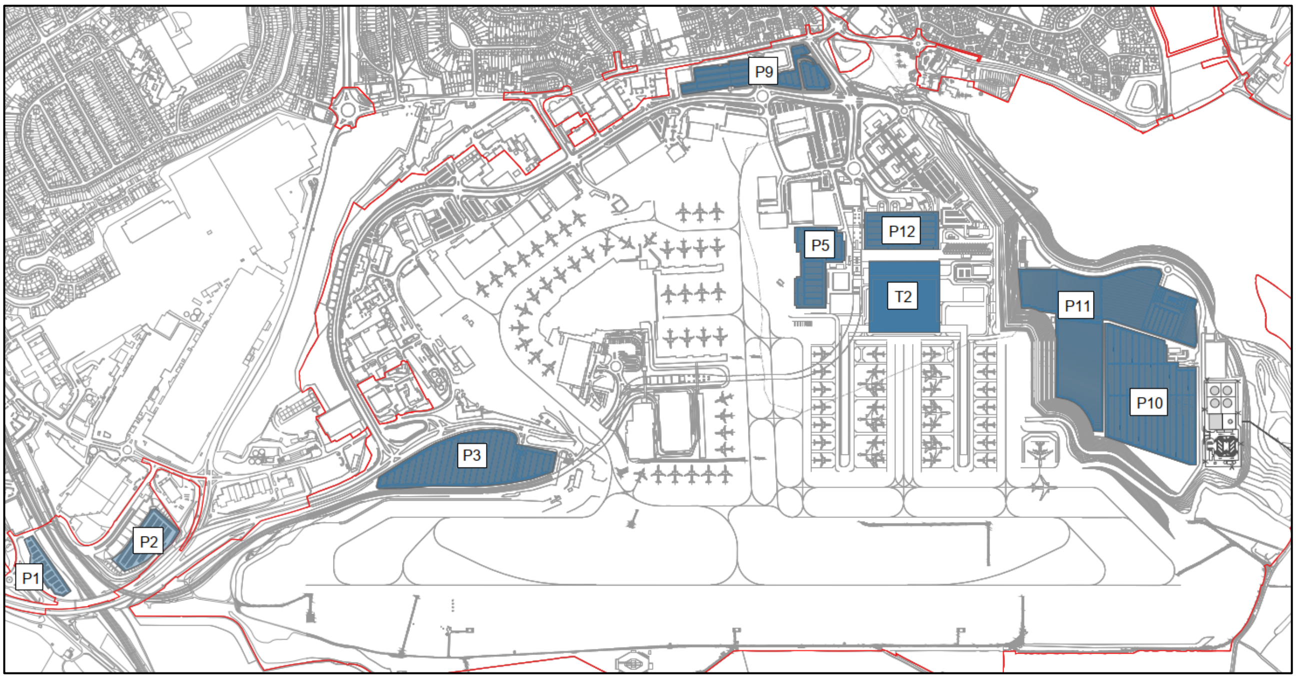


Figure 4-4 Proposed Locations of Solar Panels



4.2.4 Site sections are not yet available, but building heights are listed in Table 4-1.

Table 4-1 Parameters of Authorised Development – Including Maximum Building Heights as listed in **Draft Development Consent Order [AS-005]**

(1) Element of authorised development	*(2) Work No.*	*(3) Maximum building height (metres)*	*(4) Maximum parameter height (metres AOD)*	*(5) Maximum work area (m²)*	*(6) Maximum volume in m³)*	*(7) Notes*
Access						
Car Park P1	4g	20.4	135.4	14,105	111,588	N/A
Car Park P5 – New Decked Car Park	4k(02)	7.7	163.2	22,536	147,303	N/A
Car Park P9 – New Decked Car Park	4o(02)	7.7	161.6	27,362	163,286	N/A
Car Park P10 – New Long Stay car park	4p(01)	5.0	142.0	28,969	–	The maximum building height applies to the PV canopies, bus shelters and barriers within this work.
Car Park P10 – Reconfiguration of New Long Stay Car Park	4p(02)	5.0	135.0	71,410	2,005	The maximum building volume applies to the welfare buildings within this work.
Car Park 11 – New Long Stay Car Park	4q(01)	5.0	137.0	45,045	2,797	The maximum building volume applies to the welfare buildings within this work.
Car Park P11 – Expanded Long Stay Car Park	4q(02)	5.0	137.0	51,789	644	The maximum building volume applies to the welfare buildings within this work.
Car Park P12 – New Terminal 2 Multi Storey Car Park	4r	17.1	170.6	25,070	315,205	N/A

4.2.5 Figure 4-3Figure 4-1 and Figure 4-4**Error! Reference source not found.** in c ombination with Table 4-1 illustrate the proposed installation locations and heights that have been assessed.

4.2.6 This assessment aligns to the Energy Statement **[APP-050]** which considers multi-storey and deck carparks and the terminal building to have roof mounted solar panels located on any or all of the proposed installation locations at the maximum building height indicated in Table 4-1.

4.2.7 As the current configuration for solar panels has not been decided, the assessment considers the two most common mounting configurations that are contemporaneously used in the UK to optimise solar panel installation performance. These consist of:

a. Southwardly angled in rows
b. East west angled in concertinaed rows

4.2.8 The traditional configuration of solar panels have been southwardly angled in rows sufficiently separated to prevent adjacent panels' shading. This configuration provides maximised generation per solar panel due to annual sunpath conditions in the UK. See reference Figure 4-5.

Figure 4-5 Roof Mounted Solar Panels Angled Southwards in Separated Rows

4.2.9 A more contemporaneous mounting configuration of solar panels is in east west angled concertinaed rows adjacent to each. This configuration provides maximised energy generation per square meter of space, even though individual panels generate less than when angled southwardly, due to the increased volume of panels per m^2. See reference Figure 4-6.

Figure 4-6 Roof Mounted Solar Panels Angled East-West in Adjacent Rows

4.2.10 This assessment considers surface parking to have shade structure mounted solar panels located at the maximum building height indicated in Table 4-1.

4.2.11 Similar to rooftop mounted applications, the two main mounting configurations described above are shown in a ground based application with southwardly facing panels in rows as shown in Figure 4-7 and east west angled concertinaed rows adjacent to each other as shown in Figure 4-8.

4.2.12 In surface parking applications where access for vehicles is required between the mounting structure vantages the per m² solar panel density potential gain is however lower and therefore less advantageous.

Figure 4-7 Carpark Shade Structure Mounted Solar Panels Angled Southwards

Figure 4-8 Carpark Shade Structure Mounted Solar Panels Angled East-West

4.2.13 Figure 4-5 to Figure 4-8 are provided to illustrate the general architectural nature of the potential solar panel deployments.

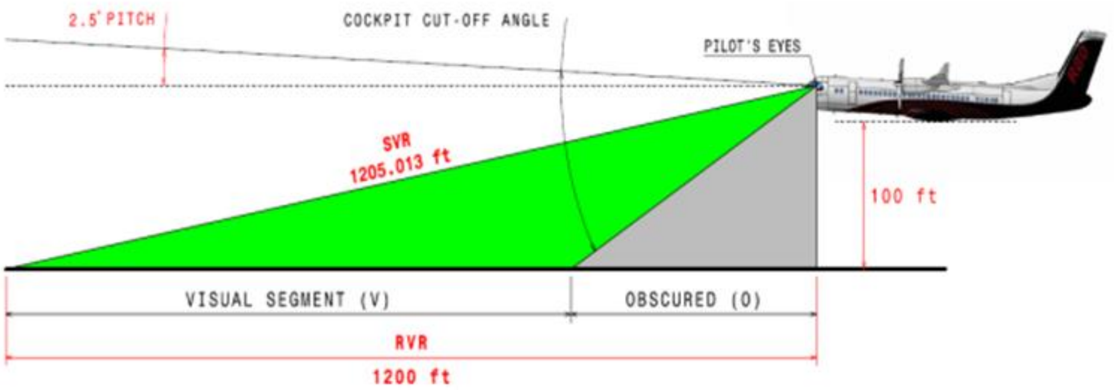
4.3 Sensitive Receptors

Aircraft Receptors

4.3.1 General guidance by the FAA has advised that proposed solar panel installations that are below the direct approach paths to airports within a distance of approximately 5 nautical miles from a runway end present a potentially sensitive glint and glare occurrence risk to landing aircraft and should be assessed by the relevant authorities/parties. While glint and glare guidance continues to evolve to keep pace with evolving solar panel technologies and their visual performance it remains typical convention and considered good practice to assess potential impacts on landing aircraft in these circumstances even though specific assessment requirements and need cases are now reduced with improved solar panel technologies.

4.3.2 Landing aircraft are considered more sensitive receptors to the occurrence of glint and glare as the primary visual focus of the aircrew is tended downward and straight towards the target runway. As aircraft descend approaching a runway the primary field of view range area reduces. Illustrated in Figure 4-9.

Figure 4-9 Illustrative Field of View Focus at 100 ft Altitude



4.3.3 Assessment guidance indicates the final approach path is the most sensitive for pilots. An industry standard precedent for focussed assessment of the final two miles of approach extended directly out from the runway end is identified as this represents the point at which a plane follows a straight-line approach to the runway and enters into a more restricted field of view on descent. A precedent for considering a 50-degree angle as the primary field of view for pilots is also established based on guidance provided by the FAA. Figure 4-10 illustrates a 2-dimensional angular assessment of the area subtended by these parameters.

Figure 4-10 Primary Field of View at 2 Mile Approach Point

4.3.4 With reference to Figure 4-10 the following is highlighted.

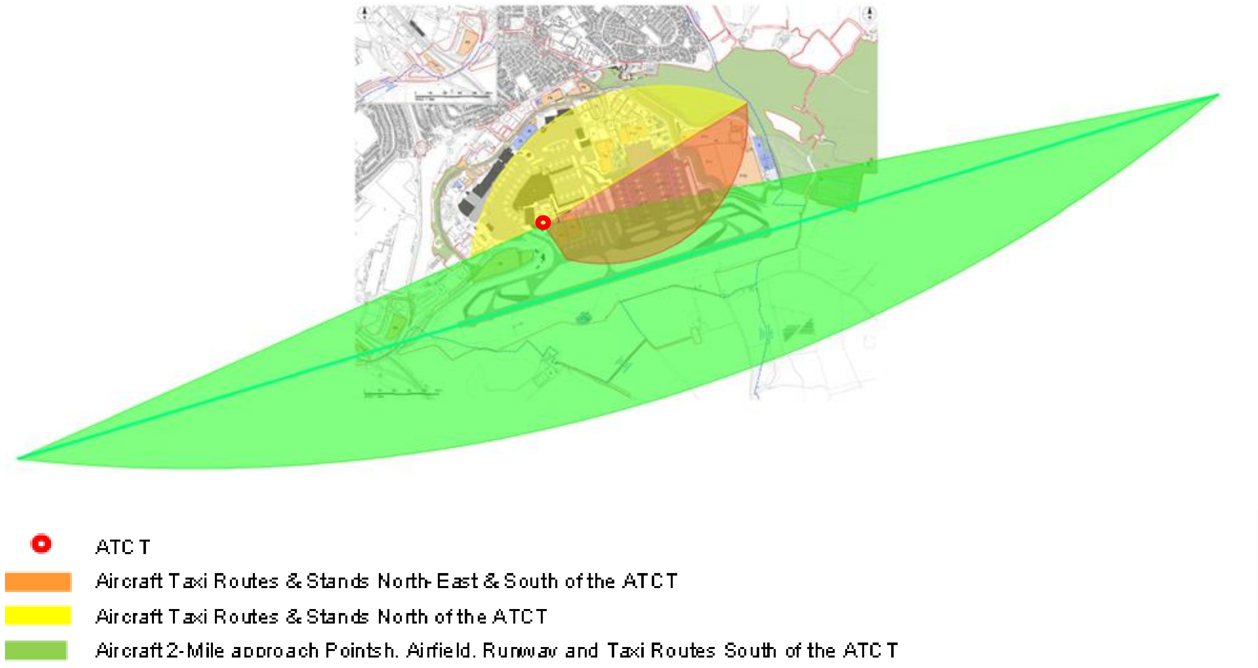
a. The proposed solar panel locations on carparks P1 and P2 (locations of which are shown on Figure 4-4 and highlighted above in Figure 4-10) sit directly under approach path within 1km of the runway end when the airport is in easterly operations mode.

b. All of the solar panel locations sit within the primary field of view of pilots at the 2-mile approach point in both easterly and westerly operations mode.

4.4 Airport Operations Buildings Receptors

4.4.1 The ATCT is the only operations building considered to be sensitive receptor in this assessment. Assessment guidance indicates clear unimpaired views of the full aerodrome from the ATCT are critical for coordinating operations. A precedent for focussed assessment of the potential occurrence of reflected solar glare in the key viewing directions of staff is identified. The current building is to be retained and currently has views of the full length of the runway, aircraft taxi routes and stand areas, without notable potential sources of reflected solar glare. Visibility is required to remain unimpaired to support ATC operations.

Figure 4-11 ATCT Key Sensitive Viewing Directions



4.4.2 With reference to Figure 4-11 the following is highlighted.

a. Proposed solar panels mounted on carparks P10 and P11 would be in the line of sight view context towards airfield taxi routes and stands east of the ATCT.

b. Proposed solar panels mounted on buildings T2, P5, P9, P12 and P15 would be in the line of sight view context towards the airfield taxi routes and stands north of the ATCT.

c. Proposed solar panels mounted on buildings P1, P2 and P3 would be in the direct line of sight towards the westerly aircraft 2-mile approach point.

d. Proposed solar panels mounted on building P3 would be in the direct line of sight towards airfield runway and taxi routes south west of the ATCT.

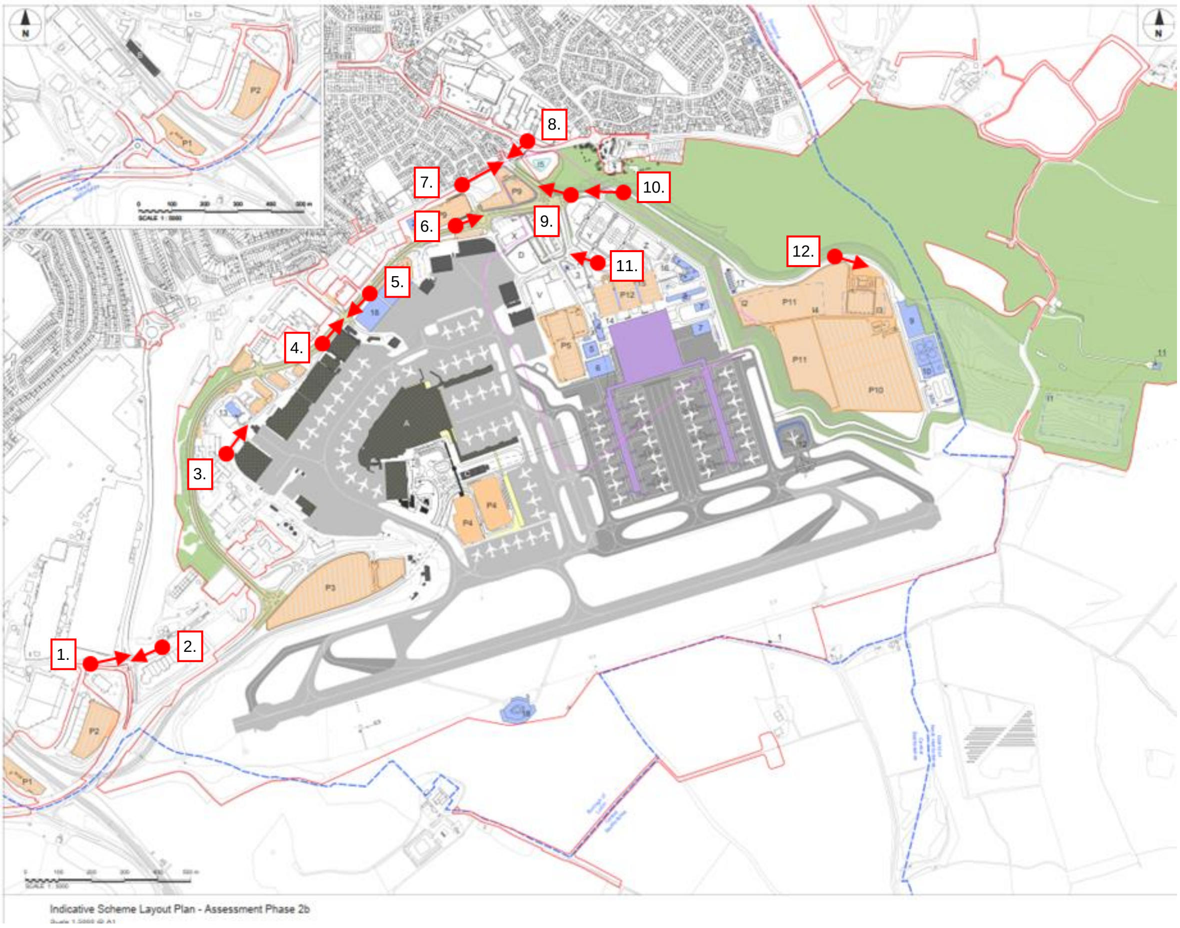
e. Proposed solar panels mounted on buildings P1 and P2 would be in the line of sight view context towards airfield runway and taxi routes south and west of the ATCT.

f. Proposed solar panels mounted on buildings P10 and P11 would be in the direct line of sight towards the easterly aircraft 2-mile approach point, airfield runway and taxi routes South and West of the ATCT.

4.5 Road Vehicular Receptors

4.5.1 Assessment guidance indicates road vehicles are considered particularly sensitive receptors when approaching junctions or pedestrian crossings. A precedent for focussed assessment of the potential occurrence of reflected solar glare in the main viewing direction of drivers is identified. The precedent is applicable to junction and pedestrian approaches on both public roads and private facilities such as multi-vehicle and pedestrian conflict spaces including airfields as shown on Figure 4-12.

Figure 4-12 - Road Vehicle Key Sensitive Viewing Directions



Key:

Road Vehicle Potentially Sensitive Viewing Directions (Preliminary Assessment)

4.5.2 With reference to Figure 4-12Figure 4-11 the following is highlighted.

a. None of the identified road / vehicle potentially sensitive viewing directions are on major national, national or major regional roads.

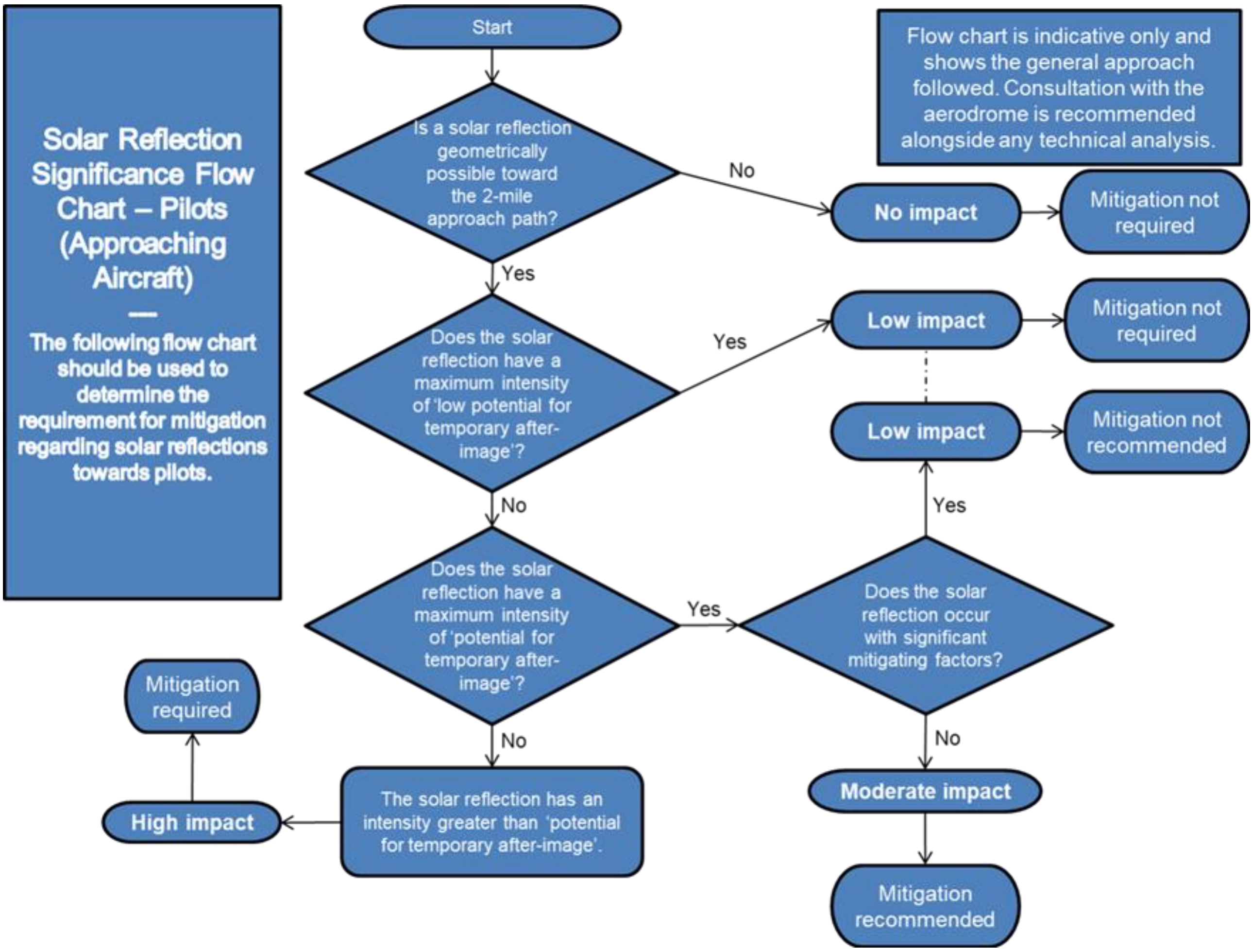
b. All of the proposed solar panel locations, through their mounting height, or in combination with potential equipment mounting configurations and specifications present a low probability for solar reflections to be significant.

5 RECEPTOR POTENTIAL IMPACT ASSESSMENT

5.1 Aircraft Receptors Impacts

5.1.1 Figure 5-1 illustrates guidance for preliminary potential impact assessment for aircraft receptors provided as part of Solar Photovoltic Glint and Glare Guidance[1] based on FAA procedures developed to ensure that proposed systems are safe and pose no risks to pilots, air traffic controllers or airport operations.

Figure 5-1 Preliminary Potential Impact Assessment Guidance and Mitigation Requirement Flow Chart for Approaching Aircraft Receptors



5.1.2 Table 5-2Table 5-1 and Table 5-2 present a preliminary assessment overview of the potential occurrence and sensitivity of reflected solar glare to landing aircraft from the proposed solar panel locations with different mounting configurations.

[1] Glint and Glare Guidance (Fourth Edition), pagerpower, www.pagerpower.com, 2022, https://www.pagerpower.com/wp-content/uploads/2022/09/Solar-Photovoltaic-Glint-and-Glare-Guidance-Fourth-Edition.pdf

5.1.3 Table 5-1 assumes all solar panels will be installed southwardly angled perpendicular to the runway in rows sufficiently separated to prevent adjacent panels’ shading.

5.1.4 Table 5-2 assumes all solar panels will be installed southwardly angled east-west angled in adjacent concertinaed rows

5.1.5 The outcomes indicate that there could be a mix of mounting configurations based on spatial constraints and the desired energy generation targets.

Table 5-1 Preliminary Reflected Solar Glare Impact Assessment with Solar Panels Installed Southwardly Angled in Separated Rows Perpendicular to The Runway

Solar Panel Locations	Potential Solar Reflection on 2-Mile Approach Path	Potential for 'Low Temporal After Image' Intensity	Potential for 'Temporal After Image' Intensity	Preliminary Impact Assessment
P1	Yes	High Probability	Low to Moderate Probability	Moderate
P2	Yes	High Probability	Low to Moderate Probability	Moderate
P3	Yes	High Probability	Low Probability	Low
T2	Yes	High Probability	Low Probability	Low
P5	Yes	High Probability	Low Probability	Low
P9	Yes	High Probability	Low Probability	Low
P10	Yes	High Probability	Low Probability	Low
P11	Yes	High Probability	Low Probability	Low
P12	Yes	High Probability	Low Probability	Low
Comments	All panel locations (T2, P1-P12) are within the main field of view at the 2-mile approach point. P1 and P2 are within the direct approach paths, while T2, P3 to P12 are outside the direct	Detailed modelling assessment required but a generally potentially favourable condition	Detailed modelling assessment required but potentially favourable condition	Assessment assumes optimised equipment specification

	approach paths. Detailed modelling assessment required for all panels.			

Table 5-2 Preliminary Reflected Solar Glare Impact Assessment with Solar Panels Installed East-West Angled in Adjacent Concertinaed Rows

Solar Panel Locations	Potential Solar Reflection on 2-Mile Approach Path	Potential for 'Low Temporal After Image' Intensity	Potential for 'Temporal After Image' Intensity	Preliminary Impact Assessment
P1	Yes	High Probability	Moderate Probability	Moderate - High
P2	Yes	High Probability	Moderate Probability	Moderate - High
P3	Yes	High Probability	Low Probability	Low - Moderate
T2	Yes	High Probability	Low Probability	Low - Moderate
P5	Yes	High Probability	Low Probability	Low - Moderate
P9	Yes	High Probability	Low Probability	Low - Moderate
P10	Yes	High Probability	Low Probability	Low - Moderate
P11	Yes	High Probability	Low Probability	Low - Moderate

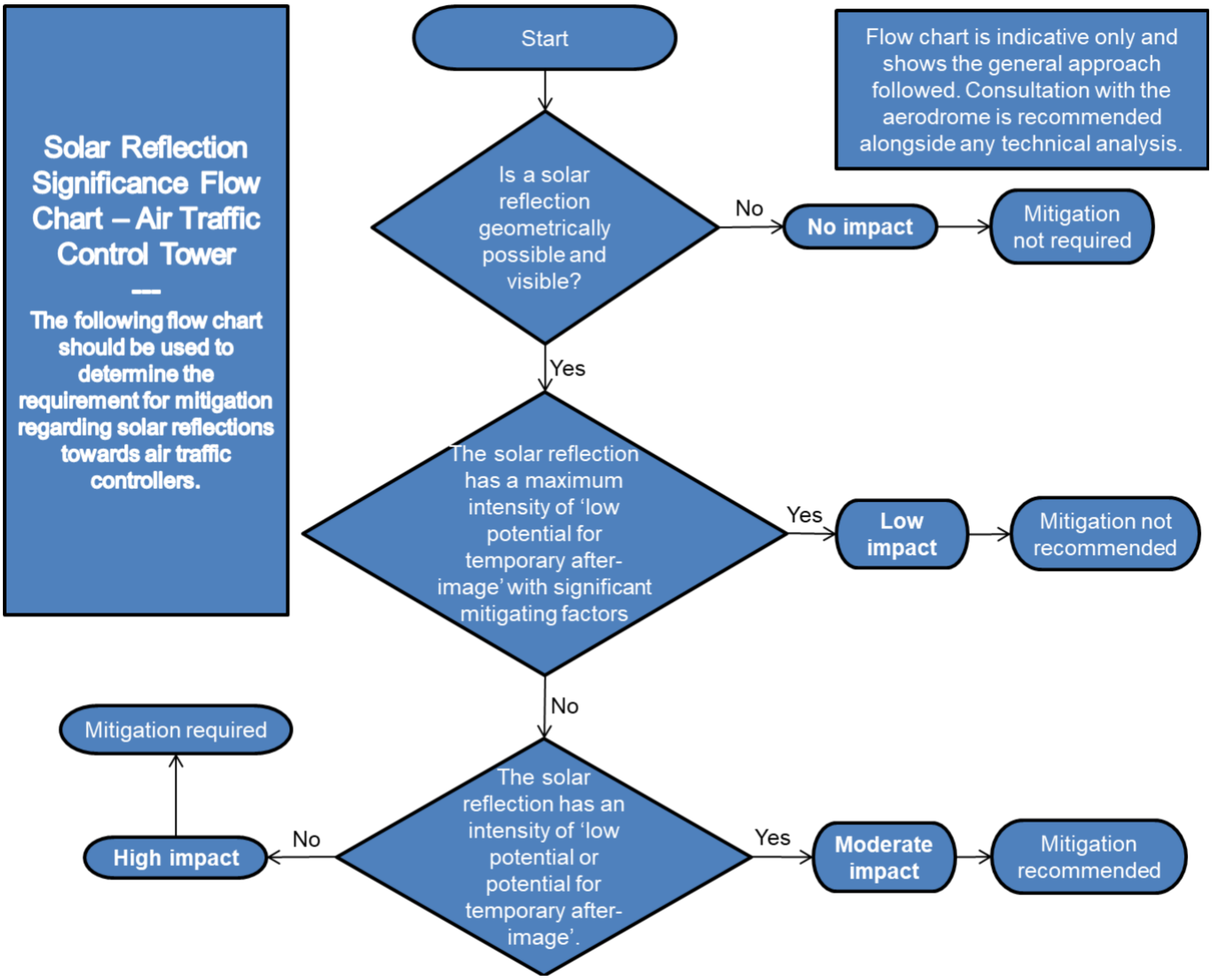
P12	Yes	High Probability	Low Probability	Low - Moderate
Comments	All panel locations (T2, P1-P12) are within the main field of view at the 2-mile approach point. P1 and P2 are within the direct approach paths, while T2, P3 to P12 are outside the direct approach paths. Detailed modelling assessment required for all panels.	Detailed modelling assessment required, potentially favourable condition reduced by east-west solar panel orientation	Detailed modelling assessment required, potentially favourable condition reduced by east-west solar panel orientation	Assessment assumes optimised equipment specification

5.1.6 The outcomes indicate that southward facing panels are likely to have slightly lower impacts for many mounting locations, however a mix of panel placement and mounting configurations could be used based on spatial constraints, mounting location and the desired energy generation targets.

5.2 Airport Operational Building Receptor Impacts

5.2.1 Figure 5-2 illustrates guidance for preliminary potential impact assessment on airport operational buildings, primarily Air Traffic Control Towers (ATCTs), provided as part of Solar Photovoltic Glint and Glare Guidance[2] based on FAA procedures developed to ensure that proposed systems are safe and pose no risks to pilots, air traffic controllers or airport operations.

Figure 5-2 Preliminary Potential Impact Assessment Guidance and Mitigation Requirement Flow Chart for ATCT



5.2.2 Table 5-3 and Table 5-4 present a preliminary assessment overview of the potential occurrence and sensitivity of reflected solar glare to the ATCT from the proposed solar panel locations with different mounting configurations.

5.2.3 Table 5-3 assumes all solar panels will be installed southwardly angled perpendicular to the runway in rows sufficiently separated to prevent adjacent panels' shading.

[2] Glint and Glare Guidance (Fourth Edition), pagerpower, www.pagerpower.com, 2022, https://www.pagerpower.com/wp-content/uploads/2022/09/Solar-Photovoltaic-Glint-and-Glare-Guidance-Fourth-Edition.pdf

5.2.4 Table 5-4 assumes all solar panels will be installed southwardly angled east-west angled in adjacent concertinaed rows.

Table 5-3 Preliminary Reflected Solar Glare Impact Assessment with Solar Panels Installed Southwardly Angled in Separated Rows Perpendicular to The Runway

Solar Panel Locations	Potential Solar Reflection on ATCT	Potential for 'Low Temporal After Image' Intensity	Potential for 'Temporal After Image' Intensity	Preliminary Impact Assessment
P1	No	NA	NA	NA
P2	No	NA	NA	NA
P3	No	NA	NA	NA
T2	Yes	High Probability	Low Probability	Low-Moderate
P5	Yes	Moderate Probability	Low to Moderate Probability	Low-Moderate
P9	Yes	Moderate Probability	Low to Moderate Probability	Low-Moderate
P10	Yes	High Probability	Low Probability	Low
P11	Yes	Moderate probability	Low to Moderate Probability	Low-Moderate
P12	Yes	High Probability	Low Probability	Low-Moderate
Comments	All proposed panel locations are within main	Detailed modelling assessment required but	Detailed modelling assessment required but generally	Assessment assumes optimised equipment specification

	field of view context in sensitive viewing directions	generally potentially favourable condition	potentially favourable condition	

Table 5-4 Preliminary Reflected Solar Glare Impact Assessment with Solar Panels Installed East-West Angled in Adjacent Concertinaed Rows

Solar Panel Locations	Potential Solar Reflection on ATCT	Potential for 'Low Temporal After Image' Intensity	Potential for 'Temporal After Image' Intensity	Preliminary Impact Assessment
P1	Yes	High Probability	Low Probability	Low
P2	Yes	High Probability	Low Probability	Low
P3	Yes	Moderate Probability	Low Probability	Low
T2	Yes	High Probability	Low to Moderate Probability	Low-Moderate
P5	Yes	High Probability	Low to Moderate Probability	Low-Moderate
P9	Yes	High Probability	Low Probability	Low
P10	Yes	High Probability	Low Probability	Low
P11	Yes	High Probability	Low Probability	Low
P12	Yes	High Probability	Low Probability	Low

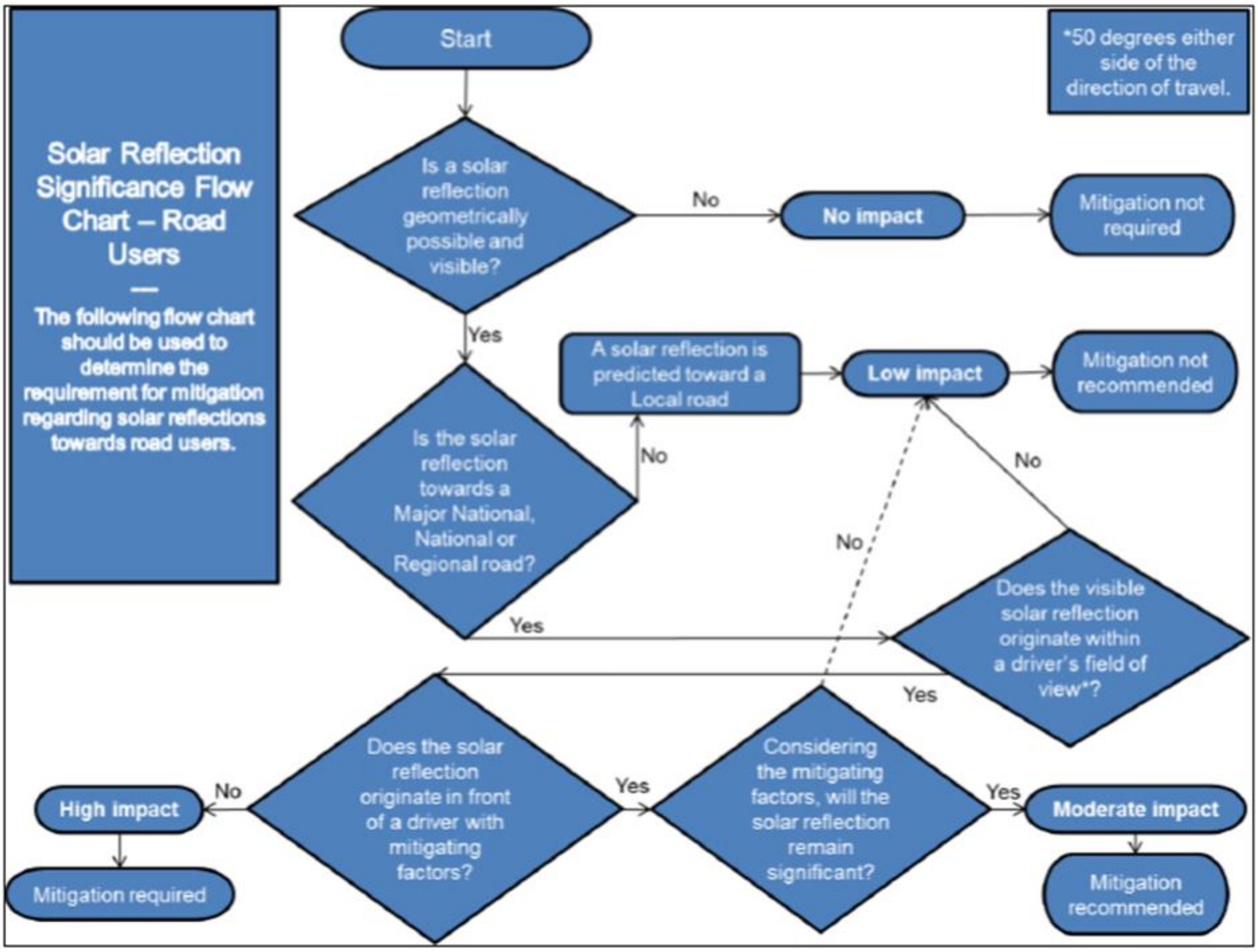
Comments	All proposed panel locations are within main field of view context in sensitive viewing directions	Detailed modelling assessment required but generally potentially favourable condition	Detailed modelling assessment required but generally potentially favourable condition	Assessment assumes optimised equipment specification

5.2.5 The outcomes indicate that southward facing panels are likely to have slightly lower impacts due to their location in relation to the ATCT, however a mix of panel placement and mounting configurations could be used based on spatial constraints, mounting location and the desired energy generation targets.

5.3 Road Vehicular Receptor Impacts

5.3.1 Figure 5-3 illustrates guidance for preliminary potential impact assessment for road users as part of as part of Solar Photovoltic Glint and Glare Guidance[3] based on typical road user considerations and mitigation.

Figure 5-3 Preliminary Potential Impact Assessment Guidance and Mitigation Requirement Flow Chart for road users



5.3.2 With reference to Figures 3.16 and 4.3, and section 3.5.2 a preliminary assessment overview of the potential occurrence and likely sensitivity of reflected solar glare to road vehicles is low.

5.3.3 Detailed modelling assessment would be considered at detailed design stage but given the outcome of the preliminary assessment, it is anticipated that generally favourable conditions would be achievable.

[3] Glint and Glare Guidance (Fourth Edition), pagerpower, www.pagerpower.com, 2022, https://www.pagerpower.com/wp-content/uploads/2022/09/Solar-Photovoltaic-Glint-and-Glare-Guidance-Fourth-Edition.pdf

6 SUMMARY

6.1 Observations and Recommendations

6.1.1 Current generation solar technology is much improved in function and materiality over earlier incarnations of panels and arrays. The current materials and finishes used in the production of solar panels has significantly reduced the potential for reflection, although it hasn't been able to be removed entirely.

6.1.2 It has been noted in current studies and guidance produced by the FAA that consider the change in technology, in some cases, such as considering effects on aircraft approach, solar panels would have a similar glint and glare effect to that of windshields on cars in a car park, glass façade buildings, or light on water. The FAA are an administrative body who have produced the leading procedures and methodology for glare analysis to ensure that proposed systems are safe and pose no risks to pilots, air traffic controllers or airport operations.

6.1.3 With reference to FAA studies and guidance, and the consideration of the technology and approaching aircraft has changed over time, the likelihood of glare to affect ATCTs is still a concern. This is largely related to the fixed nature of the cab location and visual clarity requirements to remain consistent to support the safety and movement of aircraft and vehicles around the airport, as well as be able to visually monitor the airport airspace.

6.1.4 Two contemporaneously adopted solar panel installation configurations have been assessed for the proposed installation locations:

a. Solar panels southwardly angled in rows sufficiently separated to prevent adjacent panels' shading
b. Solar panels mounted in east west angled concertinaed rows adjacent to each

6.1.5 Each configuration presents a different capability for energy generation and returns benefits. Each configuration can present different reflected solar glare advantages depending on the relative installation and receptor location details. Preliminary assessment suggests the following:

a. The deployment of a combination of the two installation configurations could be advantageous.
b. Different installation locations, and mounting configurations, pose different potential reflected solar glare impact levels to different receptors.
c. Reflected solar glare impacts on landing aircraft from all proposed locations other than P1, P2 and P3 could be low and with suitable installation design guided by further analysis locations P1, P2 and P3 may also have low impact.
d. Reflected solar glare impacts on the ATCT aircraft from all proposed locations could be low with suitable installation design guided by further analysis.

e. Reflected solar glare impacts on road vehicle users from all proposed locations could be low with suitable installation design guided by further analysis.

6.1.6 Given the arrangements of Luton Airport and the maximum parameters used in assessment that are aligned with the outline design of the proposals, the potential for glare has been identified for both a southward facing or east-west orientated installation. As the designs and the site proposals are refined, a more detailed analysis can be made regarding the potential for reflected solar glare impacts to further inform the design development and planning process. This would constitute a detailed computational analysis that considers both site conditions (development height and footprint / roofprint) and the potential for reflected solar glare based for the optimal panel placement and configuration.

6.1.7 The assessment done to date is based on the outline design and possible mounting locations and indicates that all buildings identified could potentially support solar panel arrays and be in keeping with good practice. The optimal placement and configuration would need to be confirmed through a calculated analysis based on the detailed design of the proposals, required power generation and solar panel specification.

GLOSSARY AND ABBREVIATIONS

Term	Definition
ATCT	Air Traffic Control Tower
FAA	Federal Aviation Administration