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Technical Aerodrome Safeguarding Assessment

Cumming Group

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December 2025







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ADMINISTRATION PAGE

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been commissioned to investigate the potential impact upon aviation activity and infrastructure associated with Manchester Airport of a proposed building development.

The proposed development is located at 78 Sackville Street, M1 3BB in Manchester, with a maximum altitude of 189.5m above ordnance datum (AOD).

Overall Conclusions

The proposed development is predicted to be visible to the Secondary Surveillance Radar (SSR) at Manchester Airport. An impact upon the SSR at Manchester Airport is unlikely to occur in practice due to the weaker nature of reflected signals, the façade composition being such that reflections will be scattered, and the advanced built-in capabilities of the radar for increasing its reliability and performance. Consultation with NATS, who safeguard the radar, is recommended to confirm the nature of the impact and determine if mitigation will be required.

The proposed development is vertically clear of the Obstacle Limitations Surfaces (OLS) for Manchester Airport and therefore no impact upon the OLS is predicted from the buildings themselves. However, cranes could breach the OLS during construction if they are not planned appropriately.

The proposed development is not predicted to impact the Instrument Flight Procedures (IFPs). Relevant clearance distances are predicted to be maintained. Buildings of similar or greater height are also located in the vicinity of the development which co-exist with the IFPs. It is possible however that a detailed IFP assessment may be requested by Manchester Airport Group (MAG), who safeguard Manchester Airport. This would need to be undertaken by an APDO. If a detailed IFP assessment is required, details of proposed cranes should also be provided.

Considerations of aviation lighting indicate that aviation lighting is a statutory requirement for the proposed development, based on the proposed height of the buildings. An aviation lighting scheme for cranes is also required for any cranes measuring 150m above ground level or more. A lighting scheme will need to be agreed with the CAA and MAG.

It is recommended that this report is provided to MAG and NATS for their comment and position on the proposed development.

Technical Summary

Secondary Surveillance Radar

The modelling has concluded that the proposed development will be visible to the SSR at Manchester Airport with consideration of screening along the line of sight profile.

The proposed development will be of similar scale to those surrounding it. No significant shadowing effects are anticipated.

The radar has specific features that reduce the radar's susceptibility to interference from buildings. A technical impact is unlikely to occur in practice due to, the weaker nature of reflected signals, façade composition being such that reflections will be scattered, and the advanced built-in capabilities of the radar for increasing its reliability and performance. The potential for some adverse effects on the radar cannot be conclusively ruled out. Therefore, mitigation may be required.

If mitigation is required, the most likely solution would be a technical fix to the radar and implemented by NATS. The solution would define the building as a known reflector and has been implemented for many developments of this type in the vicinity of SSR.

Consultation with NATS is recommended to confirm their position on the proposed development. It is recommended that details of the proposed development, including materials and detailed elevations are provided during consultation.

Obstacle Limitation Surfaces

The proposed development is vertically clear of the OLS and beneath the Outer Horizontal Surface (OHS) for Manchester Airport. The minimum margin of clearance is 17.28m.

Despite the proposed development's clearance of the OLS, cranes could breach the OLS during construction if they are not planned appropriately. Any cranes less than 17m above the maximum height of the development are predicted to be clear of the OLS.

Instrument Flight Procedures – High-Level

A high-level review of the IFPs relative to the proposed development indicates sufficient clearances between the proposed development and aircraft flying procedures. There are also taller existing buildings in the surrounding area that already co-exist with the current IFPs. Therefore, no impact upon the IFPs is predicted. It is possible however that a detailed IFP assessment may still be requested by MAG. This would need to be undertaken by an APDO. If a detailed IFP assessment is required, details of proposed crane locations, heights, and jib radius should be provided.

Aviation Lighting and Crane Usage – High-Level

The following is true regarding the proposed development:

- The proposed development itself does extend above 150m agl (the development has a maximum height of 150.5m agl);
- The building does not infringe the OLS;
- Cranes may breach the OHS and will likely extend to 150m agl or more. Cranes that do breach the OLS, or exceed to 150m agl or more, will require aviation lighting.

On this basis, aviation lighting is mandatory for the building structure as per the associated Air Navigation Order guidance, and crane lighting is required for any cranes above 150m agl.

It is recommended that the developer applies for a crane permit from the CAA eight weeks in advance. It is considered likely that Manchester Airport Group may request a crane operations scheme.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 63 countries internationally.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems. Over the years, the company has expanded into numerous fields including:

- Renewable energy projects;
- Building developments;
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 BACKGROUND

1.1 Introduction

Pager Power has been commissioned to investigate the potential impact upon aviation activity and infrastructure associated with Manchester Airport of a proposed building development.

The proposed development is located at 78 Sackville Street, M1 3BB in Manchester, with a maximum altitude of 189.5m above ordnance datum (AOD).

Building developments have the potential to affect aviation operations in numerous ways. The most common impacts relate to building developments as physical obstructions both to aircraft and wireless signals used for radar and radio systems. This assessment has identified and assessed all the aviation constraints for the proposed development.

In detail the report includes:

- Proposed development details;
- Radar impact assessment for the Manchester Airport Secondary Surveillance Radar (SSR);
- Obstacle limitation surfaces (OLS) assessment for Manchester Airport;
- High-level assessment of Instrument Flight Procedures (IFPs);
- Commentary on crane usage and lighting requirements;
- Overall conclusions and recommendations.

Following the results of the analysis, conclusions and recommendations are made.

1.2 Proposed Development Site Plan and Location

The location of the site is shown in Figure 1 below. The proposed development will consist of four tower blocks of 50, 17, 33, and 24 stories respectively.

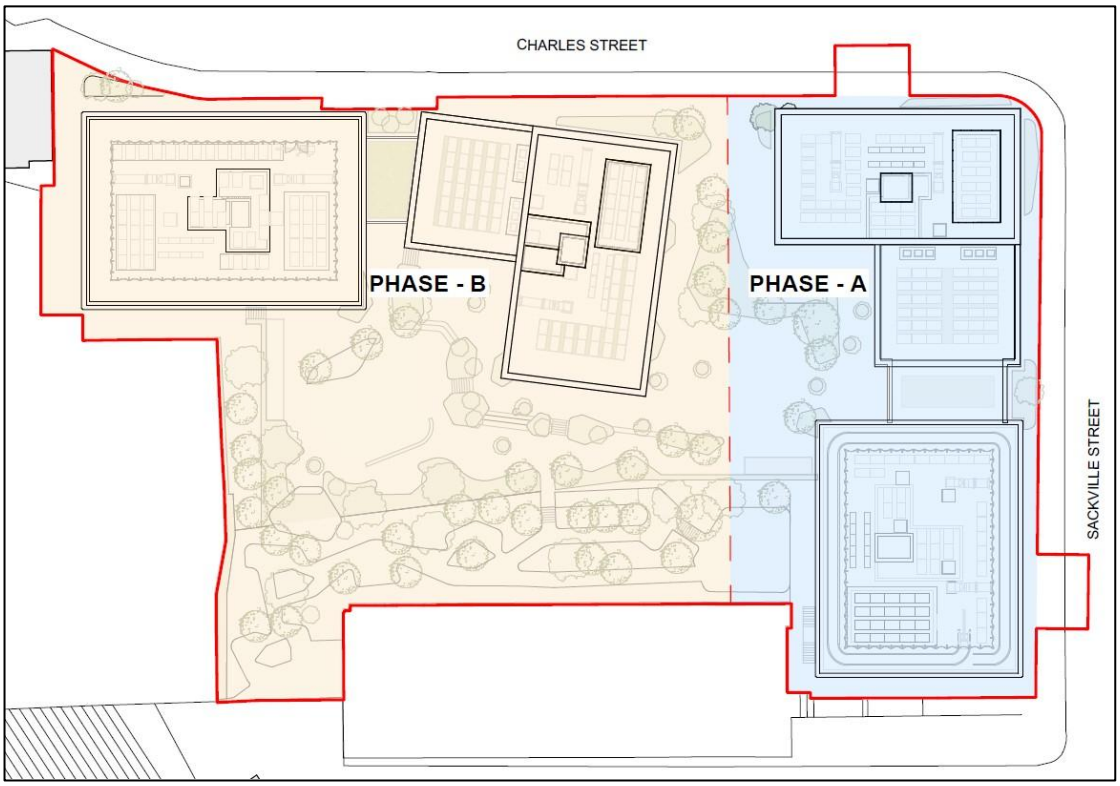


Figure 1 *Proposed site location*

The project description is as follows:

(a) *Partial removal of existing structures and erection of two buildings comprising purpose-built student accommodation (sui generis), one of 50 storeys and one of 17 storeys with an 8-storey link, together with associated amenity space, external landscaping, highways works, and change of use of the Pendulum Hotel to purpose-built student accommodation; and*

(b) *Removal of remaining existing structures and erection of two buildings comprising purpose-built student accommodation (sui generis), one of 33 storeys and one of part-24 and part-8 storeys with a 1-storey link, together with associated amenity space, external landscaping, and highways works.*

Figure 2 on the following page shows the red line boundary and building footprint (pink outline), overlaid upon aerial imagery.

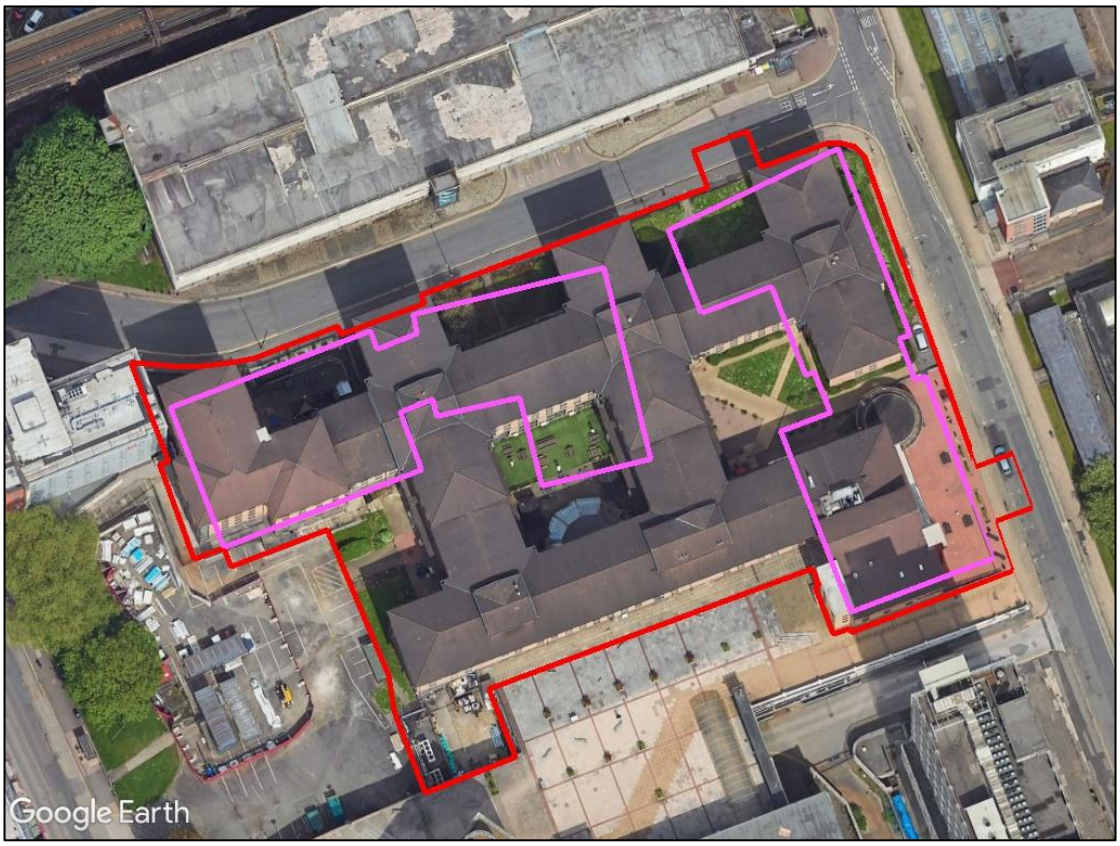


Figure 2 *Building footprint*

The four tower blocks have the following maximum heights:

- 50 stories at 189.5m amsl;
- 33 stories at 138.3m amsl;
- 24 stories at 111.75m amsl;
- 17 stories at 92.10m amsl.

All four tower blocks have been assessed in detail within this report due to their heights and potential to cause a significant impact upon aviation activity and infrastructure.

The remaining parts of the proposed development are in keeping with other low-rise buildings in the area and are therefore not predicted to have a significant impact upon aviation activity and infrastructure in the vicinity of the proposed development. Section 1.4 shows a 3D representation of the buildings in the context of the existing urban environment.

1.3 Elevation Diagrams

The general elevation plans[1] for the proposed development shown in Figure 3 on the following page and Figure 4 on page 14.

[1] Source: 10346-SHA-Z0-A-B5D8-G100-EL-EE-001, 10346-SHA-Z0-A-B5D8-G100-EL-EN-001

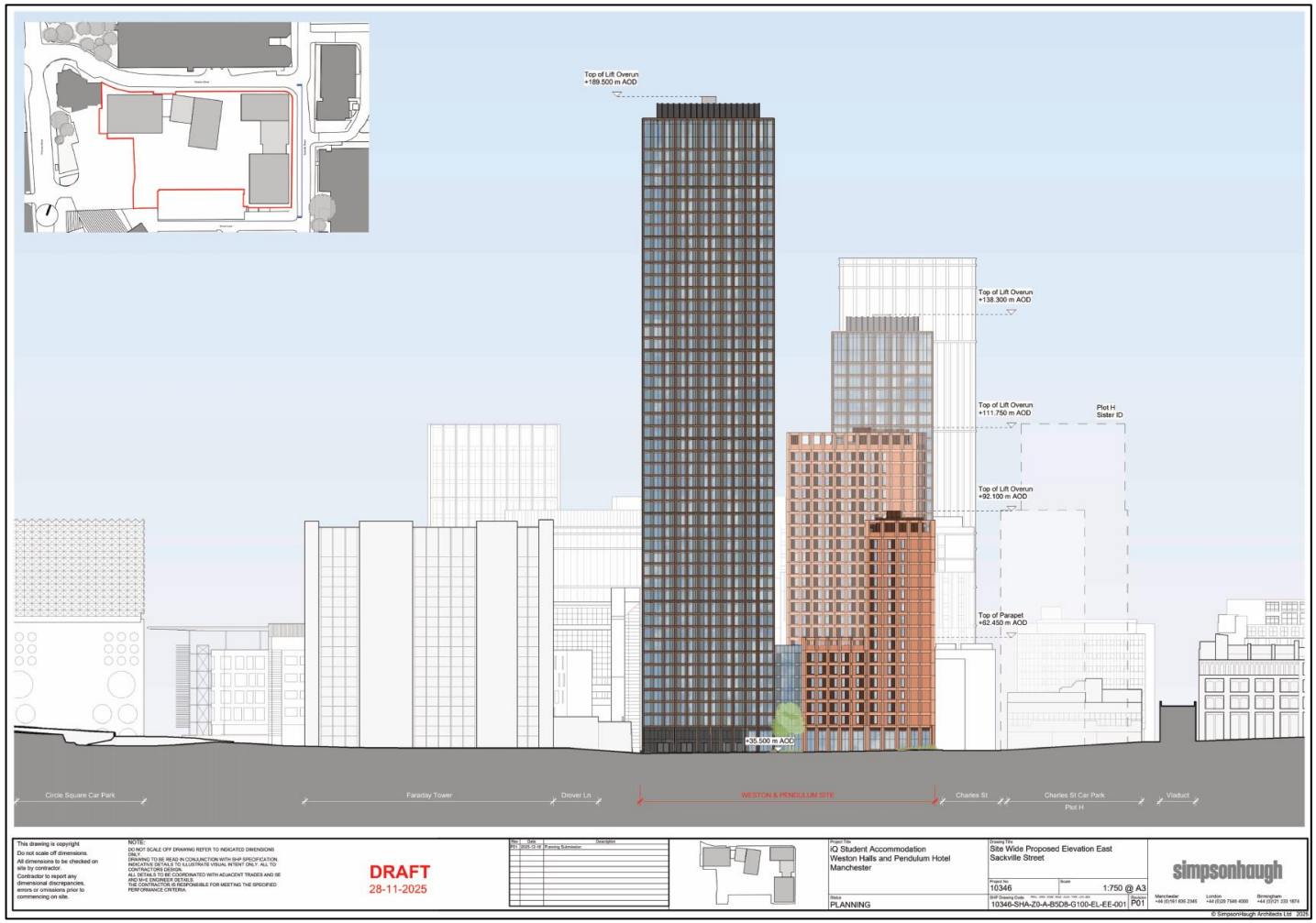


Figure 3 *Site Wide Proposed Elevation East*

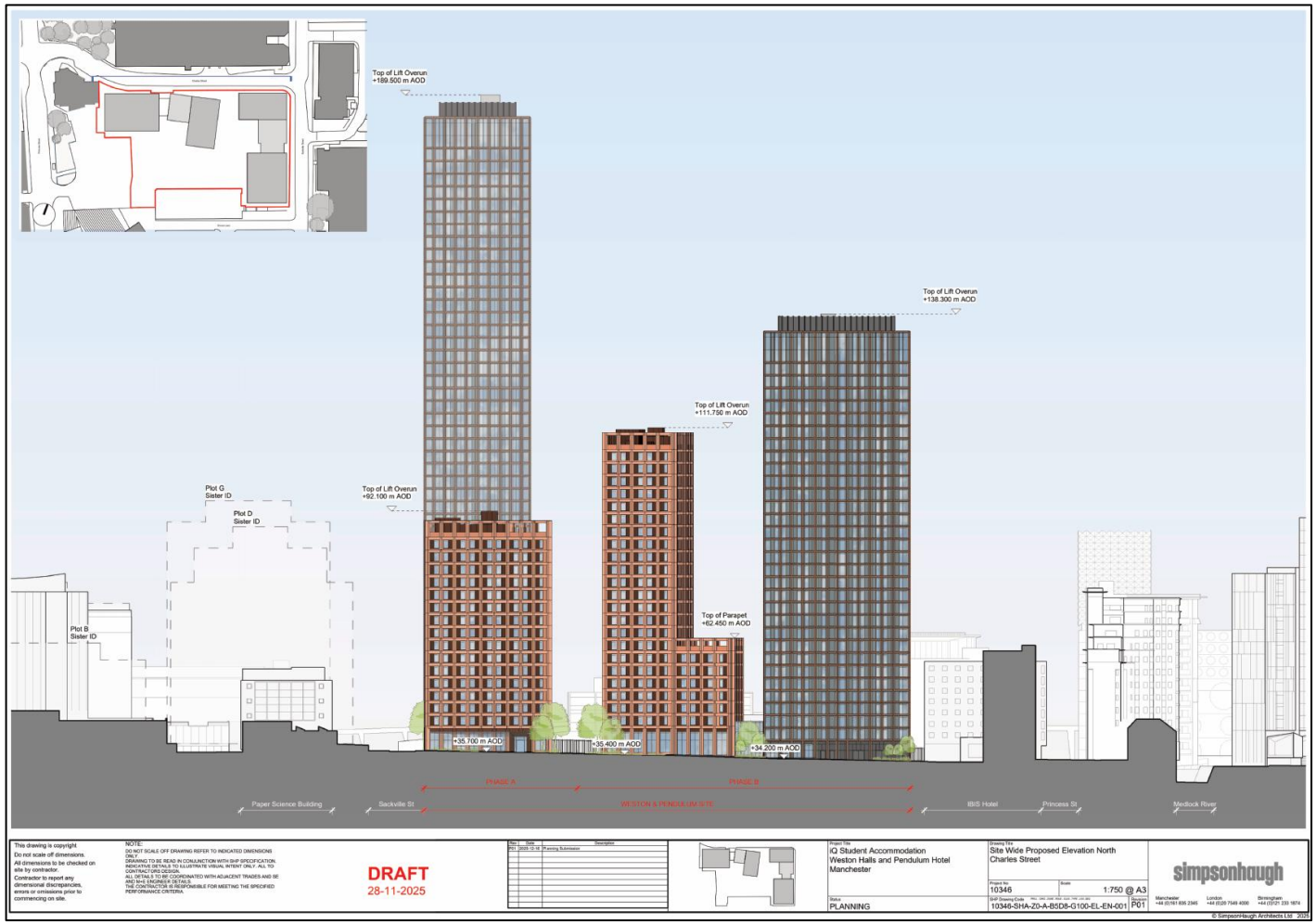


Figure 4 *Site Wide Proposed Elevation North*

1.4 3D Building Visualisation

The coordinates for the tower blocks have been extrapolated from the site drawing and are presented in Appendix A. A representative 3D visualisation of the proposed development is shown in Figure 5 below.

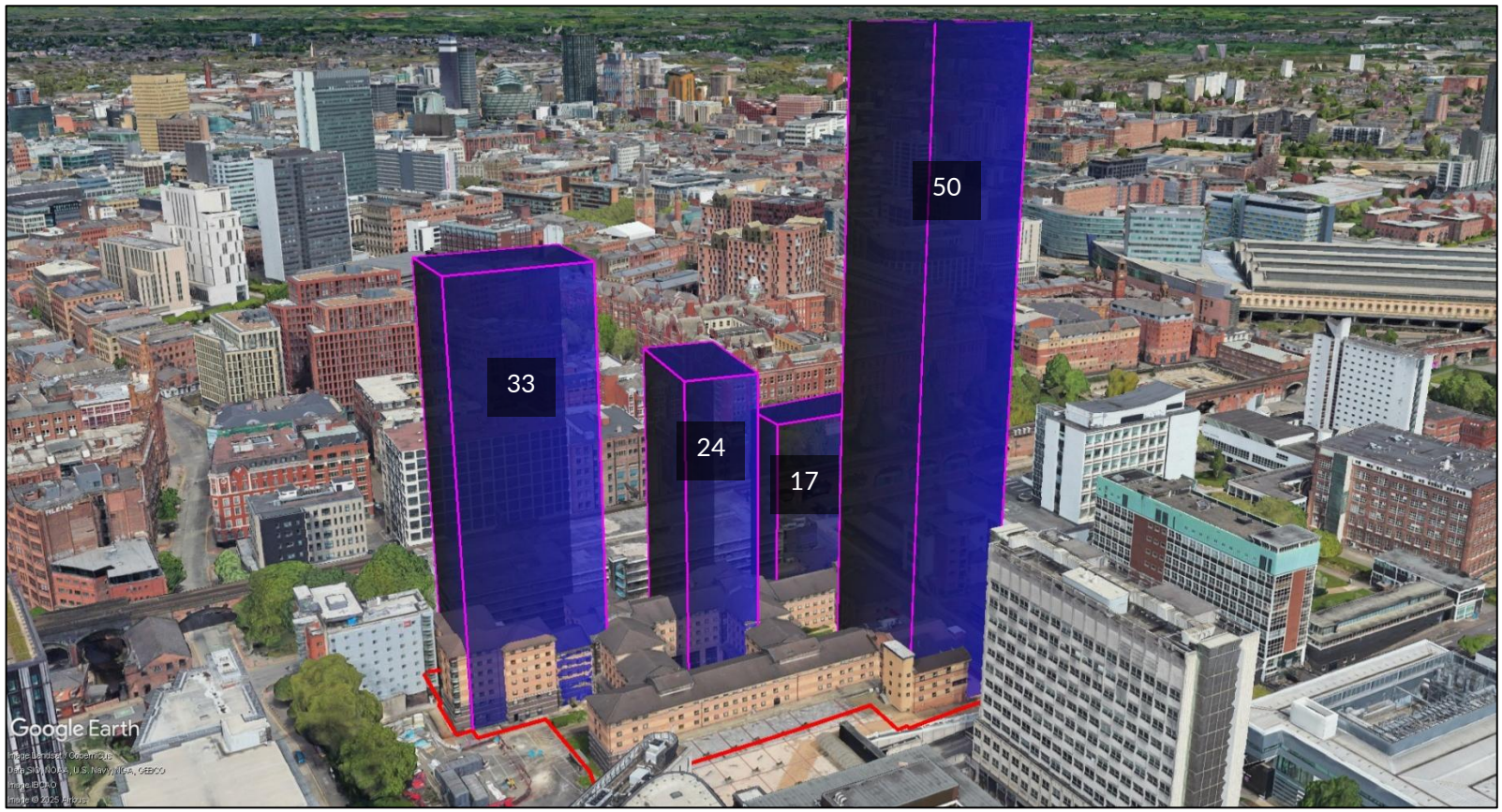


Figure 5 *3D building visualisation (number of storeys in each tower labelled)*

2 MANCHESTER AIRPORT DETAILS

2.1 Aerodrome Details

Manchester Airport is a CAA-certificated airport and is approximately 12.5km south south-west of the proposed development. The location relative to the proposed development is shown in Figure 6 below.



Figure 6 *Location of Manchester Airport relative to the proposed development*

The aerodrome chart for Manchester Airport is shown in Figure 7 on the following page.

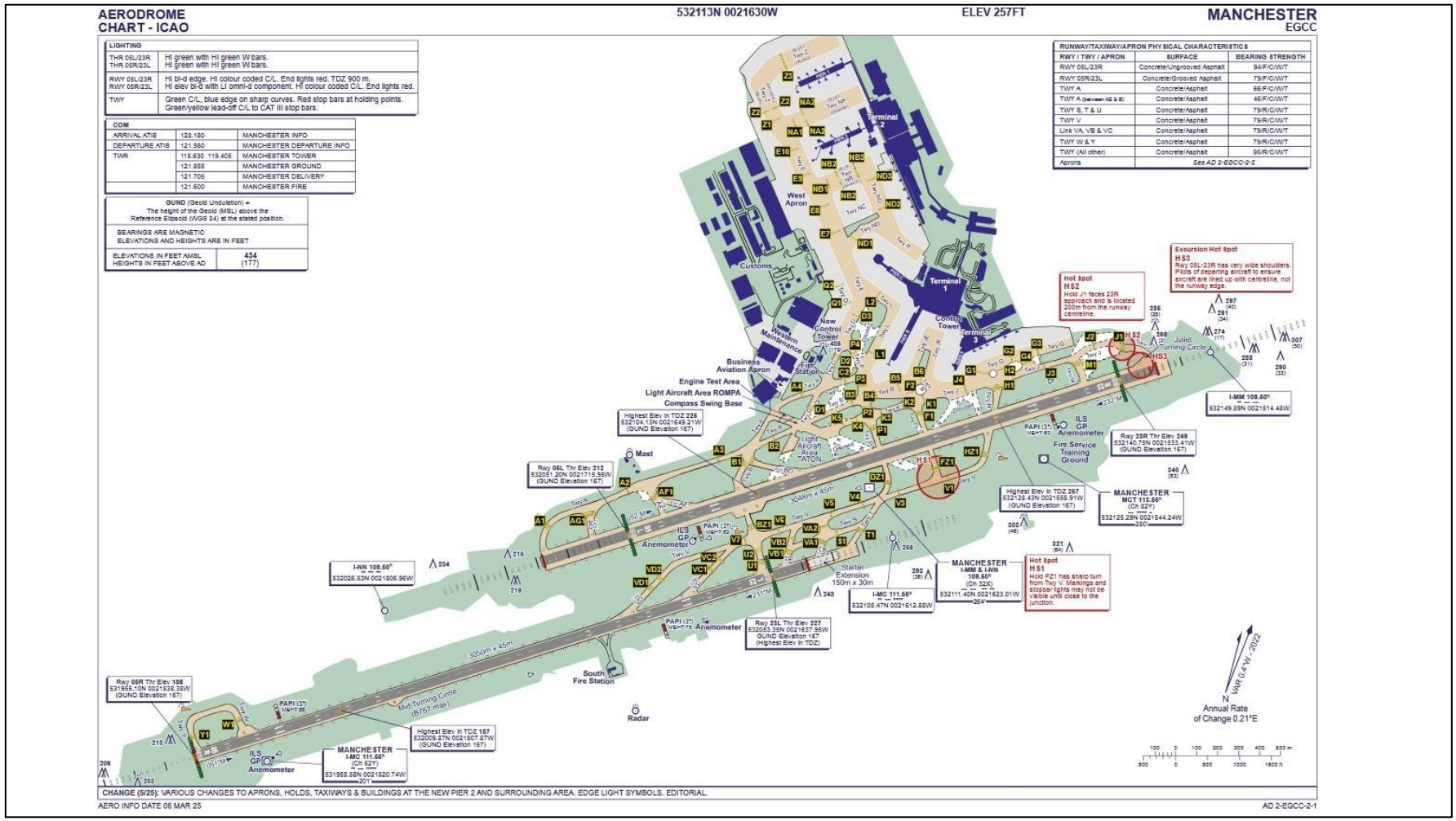


Figure 7 *Aerodrome Chart for Manchester Airport*

3 RADAR INFORMATION

3.1 Radar Data

Table 1 below provides the details for the assessed Manchester Airport SSR radar. Radar data has been provided by NATS.

Radar	Secondary Surveillance Radar (SSR)
Overall radar altitude above mean sea level	97m
Distance between the proposed development and radar	15.2km
Average grid bearing from radar to proposed development	12.2°

Table 1 *Manchester Airport SSR radar location details*

3.2 Radar Types and Usage

There are two radar situated upon the metal lattice tower. The lower radar is a non-cooperative PSR, the taller is the co-operative SSR which has been assessed within this report.

SSR broadcast interrogating radio signals that are detected by aircraft with on-board transponders. The transponder responds by broadcasting a radio reply which normally contains identification and altitude information. The SSR determines the aircraft's horizontal position from the direction the antenna is orientated and the time taken to receive a response from the interrogation.

Both radar will be used by air traffic controllers to provide approach services to aircraft landing at and departing Manchester Airport. Both radar will also be used by air traffic controllers at national air traffic control centres to provide services to en-route aircraft.

The radar of significance with respect to the predicted impact is the SSR. The PSR is not expected to be significantly affected.

4 RADAR INTERFERENCE

4.1 Overview

An overview of the various possible interference mechanisms is presented in the following subsections.

4.2 Interference

Buildings, structures and terrain can interfere with SSR. The level of interference normally depends on the size of the interfering structure and its distance from the radar. A larger structure closer to the radar is more likely to interfere than a smaller structure which is further away. The two predominant forms of interference are considered. These are listed in the following sub-sections.

4.2.1 Reflections

Reflections from a structure can potentially result in genuine aircraft returns being plotted in the wrong place as a result of the structure reflecting signals in a specular (mirror-like) way. This means that an air traffic controller could mis-manage aircraft, leading to safety implications.

Both in-bound and out-bound signals are weakened due to reflections because they are reflected by a structure in both directions.

4.2.2 Shadowing

Radar signals are weakened by physical obstacles. The most significant signal blocking is often caused by terrain. Large obstructions within a radar's area of coverage can have a 'shadowing' effect, reducing the signal strength immediately behind them.

This effect is most pronounced immediately behind the structure and becomes less pronounced with distance. This is important because it means a structure's 'shadow' does not block radar coverage indefinitely, and the areas with the highest losses should be considered in an operational context.

Both in-bound and out-bound signals are weakened by shadowing because signals are attenuated by a structure in both directions.

4.3 SSR Capabilities

The radar is a Secondary Surveillance Radar (SSR) fitted with a Large Vertical Aperture (LVA) antenna. The radar is located to the south of Manchester Airport. It is a Mode S monopulse SSR supplied by Raytheon Systems Limited as part of a nationwide contract to upgrade NATS' national network of twenty sites.

The radar is understood to be a Condor 300 dual channel system with Mode S capabilities. This radar has a range of advanced built-in capabilities for increasing its reliability and performance. Specific features that reduce the radar's susceptibility to interference from buildings are listed in Table 2 on the following pages.

Feature	Form of interference	How feature reduces interference	Additional Information
Integral Tracking Function	Reflections	More likely to determine return is genuine if it moves as an aircraft return is expected to.	Ensures good false target suppression.
Refined Algorithms	Reflections and Shadowing	Experience on many sites used to enhance performance.	Ensures good performance in complex environments.
Identification and rejection of false replies	Reflections	False returns are rejected	If two or more replies are identified from the same source all but the first is rejected.
Side Lobe Suppression	Reflections	False returns arising from antenna sidelobes are rejected	P1 and P2 pulses are used. This is an encoding system which enables sidelobe signals to be detected by comparing pulse sizes.
Sensitivity Time Control (STC)	Reflections	Removes reflections	Removes relatively low amplitude replies
Minimum Detection Signal Level (MDS)	Shadowing	Maximises radar coverage whilst minimising noise detections	-
Dynamic Threshold	Shadowing	Weak signals stronger than any interference signals are detected.	-
Reply to Reply Correlation	Reflections	Multiple replies required for target processing	Single reply reports are rejected.

Feature	Form of interference	How feature reduces interference	Additional Information
FRUIT[2] Rejection	Reflections	Track initiation only allowed if report contains two or more correlating replies in the same SSR mode	e.g. two or more Mode A replies
Track Processing	Reflections and Shadowing	Improvements are made in target location using history of target position.	Improvements made when confidence in location information is low
False Target Processing	Reflections	Advanced processing that applies a series of tests to identify and reject false returns	Techniques include: 1: Check whether Mode A code is unique 2: Check "known" reflection zones 3: Use geometric analysis for checking reflection zones 4: Self adaptive processing

Table 2 *Radar features for reducing interference*

[2] FRUIT – False Replies Unsynchronized in Time

5 RADAR LINE OF SIGHT ANALYSIS

5.1 Methodology

The approach taken within this report is presented in the following section.

5.1.1 Technical Assessment

- Radar line of sight assessment based on the tower coordinates assessed at their relative height above ground level;
- Screening assessment to determine whether existing buildings and/or landscape features would hide/shield the proposed development from the SSR;
- Consideration of the distance from the SSR.

5.1.2 Cumulative Assessment

- Assessment of the predicted impact in the context of the existing environment has been undertaken.

5.2 Radar Line of Sight Analysis

Figure 8 on the following page shows the line-of-sight chart for the south-eastern vertex of the 48-storey tower (the point with the greatest visibility to the SSR). Information regarding the methodology or the additional line of sight charts can be provided upon request. The tower height above ground level has been adjusted to account for the terrain height based on OSGB36 terrain data at that particular location.

The box labelled 'certainty' in Figure 8 provides the distance (in metres) by which the proposed development is or is not within line of sight to the assessed radar.

In this case the proposed development would be fully visible considering bare earth terrain.

5.3 Line of Sight Results – Bare Earth Terrain

A summary of the line of sight assessments for each tower is presented in Table 3 below. The results are shown for the most visible vertices of each tower.

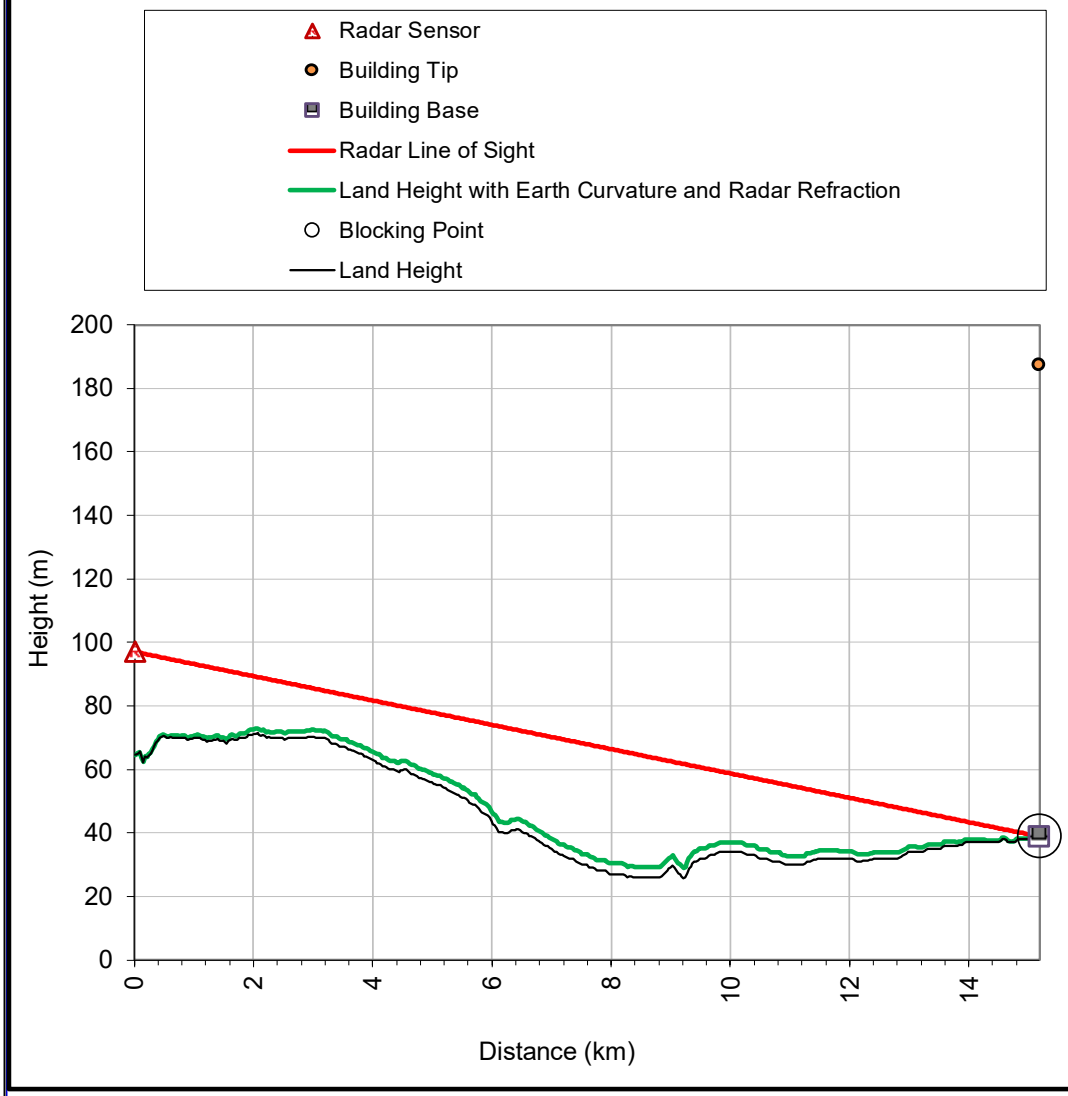
Tower / Vertex	Result (Bare earth terrain)
50 storey / South-eastern	The building is visible by a margin of 150.6m
33 storey / North-western	The building is visible by a margin of 99.65m
24 storey / South-western	The building is visible by a margin of 72.85m
17 storey / All	The building is visible by a margin of 53.15m

Table 3 *Summary of Line of sight results for each assessed tower – bare earth terrain*

Radar Line of Sight Calculation

Manchester Airport SSR

Manchester SSR Line of Sight	
Vertex	48S1
Result	VISIBLE
Certainty	148.4 metres



Building Height (m)	148.4428124
Terrain Elevation (m)	38.9
Building Location	E384532 N397493
Distance to radar (km)	15.2
Blocking Point Location	E384532 N397493
Distance to BP (km)	0.0

Additional Analysis	
Angle (Radar to Tip)	0.290 degrees up
Maximum Tip Height	0.00 metres

See Appendix for further information

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Figure 8 *Radar line of sight chart*

5.4 Additional Screening Analysis

The modelling described in the sections above accounts for the intervening terrain. It does not account for additional obstructions within the radar line of sight e.g. buildings or vegetation. A review of additional screening has therefore been undertaken.

Figure 9 on the following page shows the line of sight towards the proposed development from the SSR. There are various buildings in between the SSR and the proposed development that would partially obscure the line of sight, however significant visibility is considered possible.

The proposed development is predicted to be visible from the SSR with consideration of additional screening. A technical impact upon the radar is therefore considered possible.



Figure 9 *Point-of-view from the SSR at Manchester Airport*

5.5 Radar Line of Sight Conclusions

The results show that the proposed development will be visible to the SSR at Manchester Airport. Existing screening in the form of existing buildings is not predicted to fully obstruct line of sight between the radar and building. Therefore, the potential for a technical impact is discussed in the following subsections.

5.6 Interference Assessment

Secondary surveillance radar broadcast interrogating radio signals that are detected by aircraft with on-board transponders. The transponder responds by broadcasting a radio reply which normally contains identification and altitude information. The SSR determines the aircraft's horizontal position from the orientation of the antenna and the time taken to receive a response from the interrogation.

Buildings, structures and terrain can interfere with SSR. The level of interference normally depends on the size of the interfering structure and its distance from the radar. A larger structure closer to the radar is more likely to interfere than a smaller structure which is further away. Two forms of interference have been considered. These are:

1. Reflections – Either in-bound or out-bound signals are reflected off a structure;
2. Shadowing – Either in-bound or out-bound signals are weakened because they are attenuated by a structure.

The proposed development's location, height, and orientation have been reviewed and the reflection and shadow zones considered at a high level.

5.6.1 Reflection Effects

The proposed development can be considered a flat façade acting as a uniform reflector. Reflection effects caused by static structures have the potential to create false targets, azimuth errors and target fading issues. These could occur when an obstruction reflects the outgoing and/or incoming radar signals between the SSR and an aircraft. To be received by the radar the signals also have to be strong enough to be detected. A radar return that is reflected via a building will be significantly weaker than a return received directly from an aircraft. Furthermore, a radar antenna is also designed to have reduced gain at very low angles to reduce ground clutter returns. Overall, radar returns that are reflected via buildings are significantly weaker than those that are received directly from aircraft.

A section of the façades of the proposed development is predicted to be visible to the radar, where reflections would be geometrically possible, and therefore concerns due to reflections are possible.

In practice, the effects from the proposed development are likely to be small due to the following considerations. Reflected signals are weaker than direct signals. The composition of the façade, made up of windows and beams, is not understood to be smooth. Therefore, any reflections are predicted to be scattered, leading to a weakened reflected signal. The radar is understood to be a Condor 300 dual channel system with Mode S capabilities. This radar has a range of specific features that reduce the radar's susceptibility to interference from buildings as shown in Section 4.3.

While a technical impact is not predicted, the potential for some adverse effects on the radar cannot be conclusively ruled out. It is therefore recommended that details of the façades, including the materials proposed and the composition (whether smooth or broken up) are provided to NATS during consultation to confirm any predicted impact.

The most common mitigation solution for building developments at this range from modern SSR is a software-based solution whereby the building information, specifically coordinates and altitudes of each building corner, are programmed into the radar system such that reflection effects can be ameliorated.

This agreement would be funded by the developer and commercially agreed with NATS via a contract ahead of starting development. Deployment of the solution is typically within six months of the final agreement between the developer and NATS, therefore it is recommended that engagement regarding the mitigation process is progressed with this timescale in mind.

It is possible that NATS would seek to limit any construction at the site to five metres above ground prior to installation of the mitigation solution (i.e. within six months of signing the mitigation agreement).

5.6.2 Shadowing Effects

Shadowing effects are predicted to be limited, because the development is already within a built-up area of Manchester city centre where buildings of a similar height are located nearby. These towers have a similar bearing as the proposed development relative to the SSR.

5.7 Assessment Conclusions

The modelling has concluded that the proposed development will be visible to the SSR at Manchester Airport.

An impact is unlikely to occur in practice due to, the weaker nature of reflected signals, the composition of the façade is not understood to be smooth leading to scattered reflections, and the advanced built-in capabilities of the radar for increasing its reliability and performance (see Section 4.3), the potential for some adverse effects on the radar cannot be conclusively ruled out.

Consultation with NATS, who safeguard the radar, is recommended to confirm their position on the proposed development. It is recommended that details of the proposed development, including materials and detailed elevations are provided during consultation.

6 OBSTACLE LIMITATION SURFACES ASSESSMENT

6.1 Overview

The Obstacle Limitation Surfaces (OLS) for Manchester Airport have been modelled with respect to the building plot coordinates. The aim is to identify whether the proposed development would infringe the OLS at Manchester Airport.

6.2 Manchester Airport Obstacle Limitation Surfaces

Obstacle Limitation Surfaces are imaginary planes defined in three dimensions for physical safeguarding purposes (i.e. ensuring that physical structures do not present a safety hazard at an airfield) and are defined around licensed airfields. The dimensions and geometry of the surfaces are constructed based on detailed rules defined in:

- For licensed aerodromes: UK Civil Aviation Authority's Civil Aviation Publication 168 for licensed aerodromes;
- For certificated aerodromes: Assimilated Regulation (EU) No. 139/2014; and,
- For military aerodromes: UK Military Aviation Authority (MAA): Regulatory Article (RA) 3512: Permanent Fixed Wing Aerodrome - Obstacle Environment for military aerodromes.

The size of the surfaces is dependent on the number of runways, their dimensions and the procedures carried out at the airfield.

Manchester Airport is a certificated aerodrome, and therefore, the OLS have been constructed according to Assimilated Regulation (EU) No. 139/2014.

Table 4 below presents a summary of the OLS assessment results.

Tower	Distance	Surface
50 storey	Clear by 17.28 metres	Outer Horizontal Surface
33 storey	Clear by 68.48 metres	
24 storey	Clear by 95.03 metres	
17 storey	Clear by 114.68 metres	

Table 4 *OLS assessment results*

The OLS for Manchester Airport are presented in Figure 10 on the following page. The proposed development building plot coordinates are shown as red crosses. Due to the scale these icons overlap and appear as a single cross.

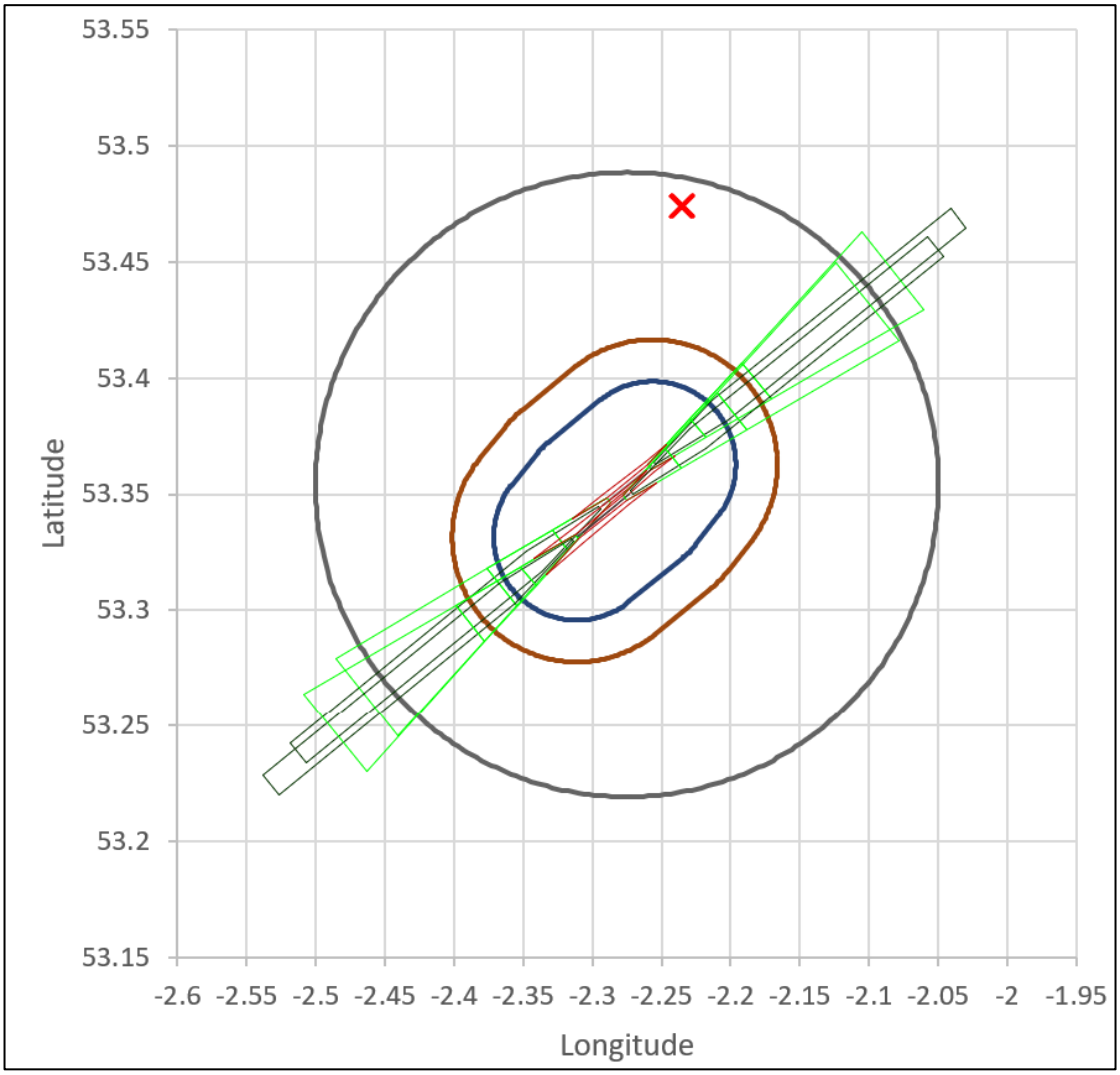


Figure 10 *Manchester Airport Obstacle Limitation Surfaces chart*

6.3 Obstacle Limitation Surfaces Conclusions

The analysis has shown that the proposed development does not infringe the OLS at Manchester Airport. The building is clear of the relevant surface, the Outer Horizontal Surface (OHS), by a minimum of 17.28 metres.

Despite the proposed development's clearance of the OHS, cranes could breach the OLS during construction if they are not planned appropriately. It is possible that a crane operation scheme will need to be agreed with Manchester Airport, and aviation lighting for cranes and the proposed development required (discussed further in Section 8).

7 HIGH-LEVEL INSTRUMENT FLIGHT ANALYSIS

7.1 Overview

Instrument Flight Procedures (IFPs) are published documents that consist of defined three dimensional routes for aircraft arriving and departing airports.

In practice, aircraft do not necessarily fly these routes exactly due to limitations on the performance of aeronautical instruments, pilots and variations in wind and pressure conditions. This means that an area around and beneath these three-dimensional routes must be kept clear of obstacles to ensure that there is no significant collision risk to aircraft flying these procedures, as shown in Figure 11 below.

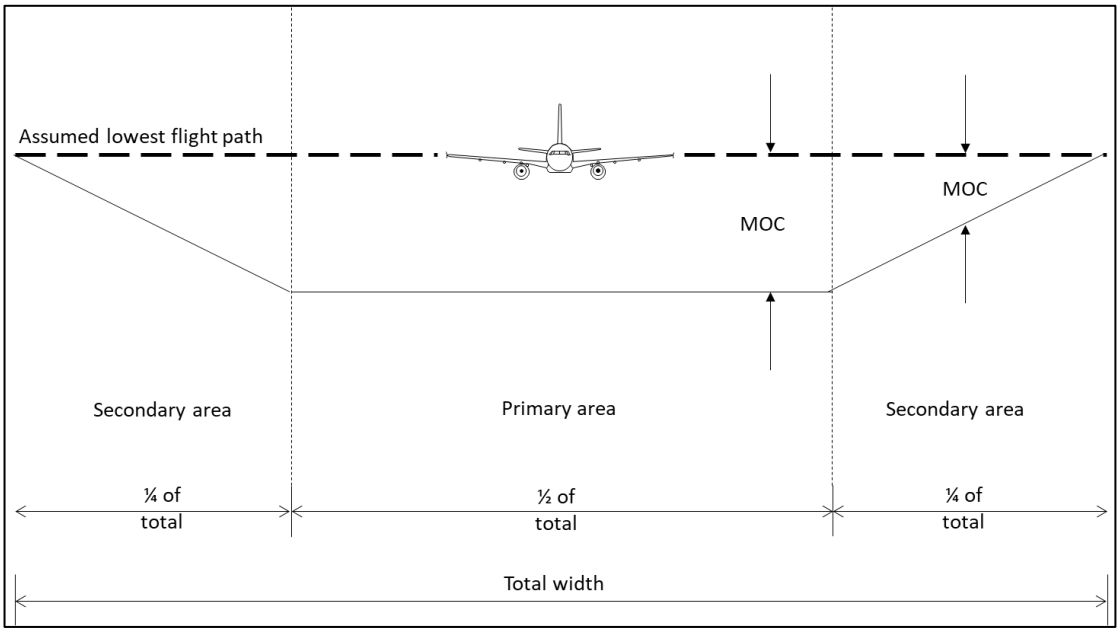


Figure 11 *Instrument Flight Procedure Minimum Obstacle Clearances*

As a general rule, IFPs are designed so that there are vertical and horizontal safety margins between the specified trajectory and surrounding terrain and obstacles. These margins vary depending on the phase of flight and whether UK, European or International rules are being considered. Nevertheless, the vertical margins are typically 300m (984 feet)[3] except in particularly mountainous regions, which Manchester is not. This means that if the vertical

[3] 300m (984ft). Procedures for Air Navigation Services, Aircraft Operations (PANS OPS) guidance states 1,000ft. It is open to interpretation whether to apply 984ft or 1000ft. In this report the former has been applied. Procedures for Air Navigation Services, Aircraft Operations, Volume II Construction of Visual and Instrument Flight Procedures. Fifth edition (2006). International Civil Aviation Organization (ICAO). Section 1-1-1-5. Part I — Section I, Chapter I. *'Minimum sector altitude (MSA). The lowest altitude which may be used which will provide a minimum clearance of 300 m (1 000 ft) above all objects located in an area contained within a sector of a circle of 46 km (25 NM) radius centred on a radio aid to navigation.'*

clearance between an IFP route and the top of the proposed development exceeds 300m (984 feet) then it will not have a significant safety impact on aircraft flying the route.

The maximum altitude[4] of the proposed development is 622 feet. This means that aircraft subject to any IFP route or limit of more than 1,606 feet will not be affected. Key IFPs are discussed in the following subsection.

Aircraft flying IFR have been assessed at a high-level by considering:

- Impact on Manchester Airport Surveillance Minimum Altitude Chart (SMAC);
- Impact on current Manchester Airport Standard Instrument Departures;
- Impact on current Manchester Airport Standard Arrival Charts;
- Impact on current Manchester Airport Instrument Approach Charts.

This has been undertaken to determine whether an impact upon IFPs is likely or whether further, more detailed, analysis is required.

7.2 Maximum Elevation Figure (MEF)

The MEF shows the maximum altitude of the highest terrain or structure in a particular quadrangle of a standard aeronautical chart. The proposed development has a maximum altitude of 622 feet, and it is located within the quadrangle where the MEF is 2,200 feet. The proposed development is below the MEF, therefore, the MEF will not be affected by the proposed development.

7.3 Area Minimum Altitude (AMA)

The AMA provides minimum obstacle clearance above all obstacles (terrain and structures) in a particular quadrangle of an aeronautical chart, normally this requirement is 2,000ft in mountainous areas and 1,000ft otherwise.

The Area Minimum Altitude shown for the quadrangle in which the development is located is 3,500 feet AMSL. The proposed development has a maximum altitude of 622 feet AMSL which is 2,878 feet below the Area Minimum Altitude. This is greater than the specified clearance of 1,000 feet (not a mountainous area). The proposed development will therefore not affect the current Area Minimum Altitude.

7.4 Surveillance Minimum Altitude Chart (SMAC)

7.4.1 Surveillance Minimum Altitude Area (SMAA)

SMACs are published to show the lowest altitude a pilot will be instructed to fly whilst receiving an air traffic control (ATC) service. The Manchester Airport SMAC[5] shows that the minimum altitude for the Surveillance Minimum Altitude Area (SMAA) is 2,400 feet AMSL and within a buffer of 5NM of the proposed development. The proposed development has a maximum altitude of 622 feet. The vertical clearance between aircraft subject to a radar control service

[4] Rounded up to the nearest foot

[5] NATS AIP, AD 2.EGCC-5-1 (cropped)

and the top of both buildings will be at least 1,778 feet. This is greater than the specified clearance of 984 feet stated in the CAA publication (CAP 777) for designing SMACs. This means that aircraft flying IFR and receiving a radar control service will have an acceptably low collision risk.

Figure 12 below shows the ATC SMAC for Manchester Airport. It presents the approximate location of the proposed development (red dot) as well as the area of tall buildings present in the surrounding city centre.

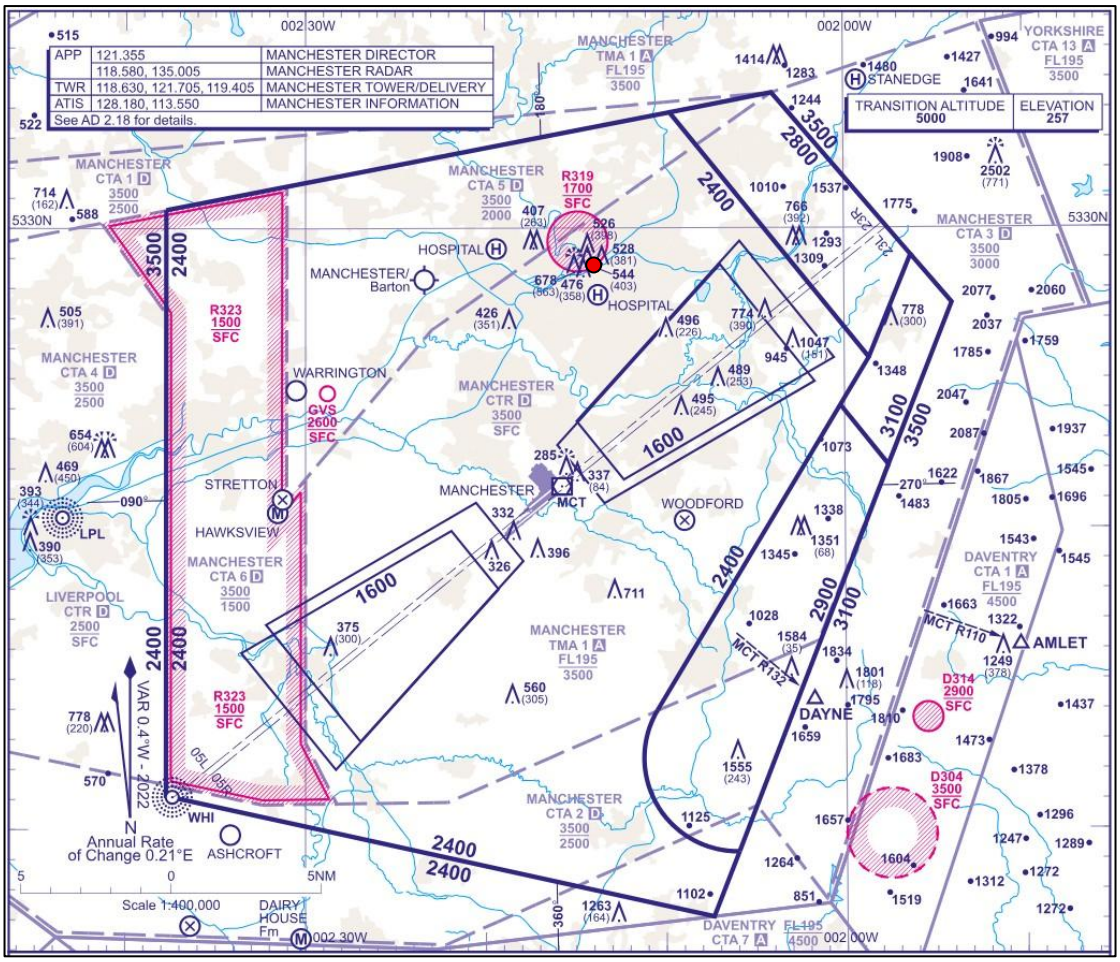


Figure 12 *Manchester Airport ATC Surveillance Minimum Altitude Chart*

During the construction phase, cranes will be present at the site that will reach elevations greater than the final building height. In principle, safeguarding concerns for cranes are the same as for building developments and so will be subject to the same constraints. There will not be any crane usage above an altitude of 1,416 feet (that would fail the clearance criteria), and therefore the SMAC is also not expected to be affected by crane usage at the site during the construction phase.

7.4.2 Final Approach Vectoring Areas (FAVAs)

There are also Final Approach Vectoring Areas (FAVA) located to the south-east of the proposed development shown on the SMAC. It is understood that there is no buffer applied to the FAVA

and therefore the proposed development is laterally clear of the FAVA, and no impacts are predicted.

7.5 Minimum Sector Altitudes (MSAs)

The procedures also show MSAs for aircraft flying within 25 nautical miles of an airport.

The MSA[6] for the sector in which the proposed development is located is 3,500ft, and the proposed development is not within 5 nautical miles of another lower sector. Therefore, the proposed development is over 2,878 feet vertically clear and therefore is not expected to impact the MSA. The MSA is also not expected to be affected by crane usage at the site during the construction phase.

7.6 Omni-Directional Departure Procedures and Standard Instrument Departures (SIDs)

Omni-directional departures are not used in practice at Manchester Airport but have been assessed as part of a conservative and thorough analysis of instrument flight procedures. If a proposed building is not predicted to infringe omni-directional departures, it can be predicted that the proposed building will not impact other departure procedures. If an infringement is predicted, more detailed analysis of specific departure procedures is undertaken.

Departure charts have been examined to identify the appropriate climb profile. The climb profile varies along and between departure procedures, the lowest profile used is 3.43%, which has been assumed throughout for simplicity. If the proposed development does not infringe under a climb profile of 3.43% it will not infringe when a steeper profile is used.

A maximum height of 1,371.4ft (418m) AMSL is allowed at the location of the proposed development. The maximum elevation of the proposed development is 622ft (189.5m). Thus the proposed development is clear of the omni-directional departures by 749.4ft (228.5m) and is not predicted to infringe this procedure.

There will not be any crane usage above an altitude of 1,371.4ft (that would fail the clearance criteria), and therefore the omni-directional departure procedures are also not expected to be affected by crane usage at the site during the construction phase.

As the proposed development and cranes are not predicted to infringe the omni-directional departures, the proposed development and cranes are also not predicted to infringe specific instrument departures.

The building and associated cranes are predicted to present an acceptably low collision risk to aircraft flying all Standard Instrument Departure routes.

[6] NATS AIP EGCC AD 2.24 -8

7.7 Standard Arrival Charts (STARs)

Manchester Airport has four published Standard Arrival (STARs) Charts. Each of these has been assessed with respect to the proposed development. Results of the assessment are shown in Table 5 below.

STAR Name	Observations	Assessed Impact	Conclusion
via ROSUN (north)	Minimum Altitude FL70	Aircraft will be 6378 ft vertically clear of the proposed development	No significant impact, no further action
via ROSUN (east)	Minimum Altitude FL70	Aircraft will be 6378 ft vertically clear of the proposed development	No significant impact, no further action
via MIRSI	Minimum Altitude FL70	Aircraft will be 6378 ft vertically clear of the proposed development	No significant impact, no further action
via DAYNE	Minimum Altitude FL70	Aircraft will be 6378 ft vertically clear of the proposed development	No significant impact, no further action

Table 5 *Standard Arrival Chart (STARs) Assessment Results*

Aircraft flying Manchester Airport's Standard Arrival Routes will be at least 6378 feet vertically clear of the building. This means that such aircraft will have an acceptably low collision risk.

7.8 Instrument Approach Charts

Manchester Airport has 14 published Instrument Approach Charts. Each of these has been assessed with respect to the proposed development. For each, the following have been considered:

- The final approach phase;
- Earlier approach phases shown on the chart;
- Missed approach procedure;
- Decision heights and circling minima;
- Minimum Sector Altitude (MSA) within 25 nautical miles.

Results of the assessment are shown in Table 6 on the following pages.

V = vertically and H = horizontally.

The proposed development is not predicted to impact the Instrument Approach Charts. No further action is recommended.

Name	Final Approach	Earlier Approach	Missed Approach	Decision and Circling	MSA	Assessed Impact	Recommended Action
ILS/DME (I-MC) RWY 05R	Clear V,H	Clear V,H	Clear V,H	Clear V,H	Clear V	None	None
ILS/DME (MCT) RWY 05R	Clear V,H	Clear V,H	Clear V,H	Clear V,H	Clear V	None	None
LOC/DME (I-MC) RWY 05R	Clear V,H	Clear V,H	Clear V,H	Clear V,H	Clear V	None	None
VOR/DME RWY 05R	Clear V,H	Clear V,H	Clear V,H	Clear V,H	Clear V	None	None
ILS/DME (I-MM) RWY 05L	Clear V,H	Clear V,H	Clear V	Clear V,H	Clear V	None	None
ILS/DME (MCT) RWY 05L	Clear V,H	Clear V,H	Clear V	Clear V,H	Clear V	None	None
LOC/DME RWY 05L	Clear V,H	Clear V,H	Clear V	Clear V,H	Clear V	None	None
VOR/DME RWY 05L	Clear V,H	Clear V,H	Clear V	Clear V,H	Clear V	None	None
ILS/DME (I-NN) RWY 23R	Clear V,H	Clear V,H	Clear V,H	Clear V,H	Clear V	None	None

Name	Final Approach	Earlier Approach	Missed Approach	Decision and Circling	MSA	Assessed Impact	Recommended Action
ILS/DME (MCT) RWY 23R	Clear V,H	Clear V,H	Clear V,H	Clear V,H	Clear V	None	None
LOC/DME RWY 23R	Clear V,H	Clear V,H	Clear V,H	Clear V,H	Clear V	None	None
VOR/DME RWY 23R	Clear V,H	Clear V,H	Clear V,H	Clear V,H	Clear V	None	None
VOR/DME RWY 23L	Clear V,H	Clear V,H	Clear V,H	Clear V,H	Clear V	None	None
RNP RWY 23L	Clear V,H	Clear V,H	Clear V,H	Clear V,H	Clear V	None	None

Table 6 *Instrument Approach Charts assessment results*

7.9 High-level IFP Assessment – Obstacle Clearance Margins Conclusions

It is likely that if an obstacle does not infringe the OLS it will not adversely affect the IFP. The OLS will not be affected by the proposed development. A high-level review of the IFPs relative to the proposed development indicates sufficient clearances. There are also similar sized existing buildings in the surrounding area that already co-exist with the current IFPs. Therefore, no impact upon the IFPs is predicted. It is possible however that a detailed IFP assessment could still be requested by Manchester Airport Group (MAG) to confirm whether impacts are possible. This would need to be undertaken by an APDO.

8 HIGH-LEVEL AVIATION LIGHTING AND CRANE USAGE CONSIDERATIONS

8.1 Overview

Aviation lighting is required where an object becomes a collision risk. This is most likely where there is an infringement of the OLS. It also becomes mandatory to have lighting where an object extends to 150m above ground level or more[7]. The following section explores the requirement for aviation lighting at a high-level.

8.2 Lighting Requirements

The following is true regarding the proposed development:

- The proposed development itself does extend above 150m agl (the development has a maximum height of 150.5m agl);
- The building does not infringe the OLS;
- Cranes may breach the OHS and will likely extend to 150m agl or more. Cranes that do breach the OLS, or exceed to 150m agl or more, will require aviation lighting.

On this basis, aviation lighting is mandatory for the building structure as per the associated Air Navigation Order guidance, and crane lighting is required for any cranes above 150m agl.

8.3 Crane Operations Scheme

It is considered likely that Manchester Airport Group may request a crane operations scheme.

The Civil Aviation Authority (CAA) should also be notified of the proposed development and any proposed cranes. All cranes and obstacle notifications to the CAA should be made to the Airspace Coordination and Obstacle Management Service (ACOMS). The registration process is via the CAA customer portal to access the ACOMS service to submit notification.

It is recommended that the developer applies for a crane permit from the CAA 8 weeks in advance.

[7] Air Navigation Order, 2016. There is a requirement unless the CAA allow otherwise. Last accessed 26.10.22.

9 CONCLUSIONS

9.1 Secondary Surveillance Radar

The modelling has concluded that the proposed development will be visible to the SSR at Manchester Airport with consideration of screening along the line-of-sight profile.

The proposed development will be of similar scale to those surrounding it. No significant shadowing effects are anticipated.

The radar has specific features that reduce the radar's susceptibility to interference from buildings. A technical impact is unlikely to occur in practice due to, the weaker nature of reflected signals, façade composition being such that reflections will be scattered, and the advanced built-in capabilities of the radar for increasing its reliability and performance. The potential for some adverse effects on the radar cannot be conclusively ruled out. Therefore, mitigation may be required.

If mitigation is required, the most likely solution would be a technical fix to the radar and implemented by NATS. The solution would define the building as a known reflector and has been implemented for many developments of this type in the vicinity of SSR.

Consultation with NATS is recommended to confirm their position on the proposed development. It is recommended that details of the proposed development, including materials and detailed elevations are provided during consultation.

9.2 Obstacle Limitation Surfaces

The proposed development is vertically clear of the OLS and beneath the Outer Horizontal Surface (OHS) for Manchester Airport. The minimum margin of clearance is 17.28m.

Despite the proposed development's clearance of the OLS, cranes could breach the OLS during construction if they are not planned appropriately. Any cranes less than 17m above the maximum height of the development are predicted be clear of the OLS.

9.3 Instrument Flight Procedures at Manchester Airport – High-Level

A high-level review of the IFPs relative to the proposed development indicates sufficient clearances between the proposed development and aircraft flying procedures. There are also taller existing buildings in the surrounding area that already co-exist with the current IFPs. Therefore, no impact upon the IFPs is predicted. It is possible however that a detailed IFP assessment may still be requested by MAG. This would need to be undertaken by an APDO. If a detailed IFP assessment is required, details of proposed crane locations, heights, and jib radius should be provided.

9.4 Aviation Lighting and Crane Usage – High-Level

The following is true regarding the proposed development:

- The proposed development itself does extend above 150m agl (the development has a maximum height of 150.5m agl);
- The building does not infringe the OLS;
- Cranes may breach the OHS and will likely extend to 150m agl or more. Cranes that do breach the OLS, or exceed to 150m agl or more, will require aviation lighting.

On this basis, aviation lighting is mandatory for the building structure as per the associated Air Navigation Order guidance, and crane lighting is required for any cranes above 150m agl.

It is recommended that the developer applies for a crane permit from the CAA eight weeks in advance. It is considered likely that Manchester Airport Group may request a crane operations scheme.

APPENDIX A – COORDINATE DATA

Assessed Building Points

The coordinates outlining the building are given below. Maximum building elevations are presented in Section 1.

Point	Longitude (°)	Latitude (°)	Point	Longitude (°)	Latitude (°)
50S1	-2.234508	53.473943	50S3	-2.235015	53.474123
50S2	-2.234673	53.474200	50S4	-2.234847	53.473868

Building coordinates – 50 storey tower

Point	Longitude (°)	Latitude (°)	Point	Longitude (°)	Latitude (°)
33S1	-2.235992	53.474264	33S3	-2.236339	53.473959
33S2	-2.236467	53.474156	33S4	-2.235870	53.474068

Building coordinates – 33 storey tower

Point	Longitude (°)	Latitude (°)	Point	Longitude (°)	Latitude (°)
24S1	-2.235437	53.474354	24S3	-2.235583	53.474046
24S2	-2.235698	53.474317	24S4	-2.235325	53.474082

Building coordinates – 24 storey tower

Point	Longitude (°)	Latitude (°)	Point	Longitude (°)	Latitude (°)
17S1	-2.235204	53.474290	17S3	-2.234881	53.474523
17S2	-2.234789	53.474384	17S4	-2.235283	53.474407

Building coordinates – 17 storey tower

APPENDIX B – LINE-OF-SIGHT METHODOLOGY

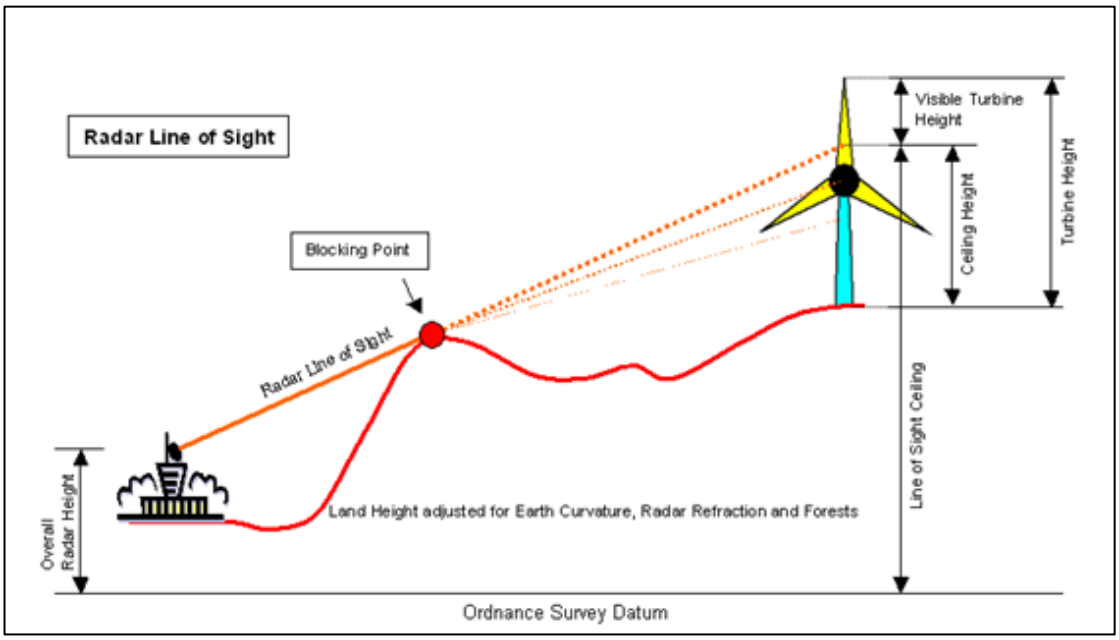
Overview

Line-of-sight Analysis is used to determine the extent to which a planned building development could be detected by a specific radar installation.

This analysis takes into account:

- The curvature of the Earth;
- Refraction of the radar signal by the atmosphere;
- The Effective Radar Height;
- The Effective Turbine Height;
- The height profile of the terrain between the radar and turbine.

The figure below shows how Radar Line-of-sight is determined, together with the various terms used in the analysis.



Radar Line-of-sight

Land height may be adjusted for Forests, Buildings or other obstructions.

Overall Radar Height

The radar height determines the Line-of-sight angle. This in turn determines the Ceiling Height. The higher the radar, the lower the Line-of-sight Ceiling will be.

The Overall Radar Height is the height of the radar radiation centre above OSGB 36 DTM terrain data.

Building Height

Higher buildings are more likely to be detected by radar than lower ones.

Earth Curvature

Curvature of the Earth limits the distance at which objects can be detected, using visual and radar techniques.

The effect of Earth Curvature increases as the separation between radar and building increases.

The effect of Earth Curvature is calculated by determining the vertical separation of two lines running between the radar and building.

The first is the arc of the great circle that passes through the radar and building. This is the shortest arc between the two points.

The second is the chord between the radar and building. This line cuts through the Earth's surface.

A curve representing the distance between the Earth's surface and the straight line is plotted.

Radar Signal Refraction

Radar Signals travel in straight lines in free space. Variations in the atmosphere cause bending of radar signals. This bending is caused by lower denser air having a higher refractive index than higher less dense air.

The result of this bending is that effective radar range is extended beyond the visible horizon. Radar system designers compensate for this effect by using a larger effective Earth Radius in their calculations. This compensation allows radar signals to be treated as straight lines, even though they are actually being refracted.

The Earth Radius is multiplied by a refraction constant k to give an increased effective Earth Radius. The standard figure used for k is 4/3. This value is known as Standard Refraction. Measured values of k in the USA range from 1.25 to 1.90[8].

The Earth Curvature curve is redrawn, by recalculating each point using the adjusted Earth radius. This is shown on the Line-of-sight charts.

Effects of variation in Refraction Constant k discussed separately shows how varying values of k can affect Adjusted Land Height.

Attenuation by Forestry and Obstructions

Areas of land between the Radar and the building development may be covered with forest, buildings or structures that effectively attenuate radar signals.

---

[8] Bean, B. R. et al. "A World Atlas of Atmospheric Radio Refractivity," U.S. Dept. of Commerce, ESSA Monograph 1, 1966. Further information for the UK and Europe is also available from Recommendation ITU-R P.453-8 "The radio refractive index: its formula and refractivity data"

Where there are large areas of forestry, or built up areas, these can be considered, and included within the Line-of-sight charts. The standard chart however does not include this.

Line-of-sight Profile

A Line-of-sight profile is generated by determining the height of a series of equally spaced points along the line between the radar and a single building. The terrain data used has the characteristics shown in the table below.

Data Source Origin	OSGB 36
Data Point Interval (m)	50
Height Data Resolution	1 metre

Terrain data characteristics

The height of a specific point is calculated by taking an average of the height values of the four surrounding data points. The average is weighted using interpolation in both X (Longitude) and Y (Latitude) directions.

The land height profile is shown on Line-of-sight chart denoted as 'Land Height'.

Adjusted Land Height Profile

The Adjusted Land Height Profile takes Terrain, Earth Curvature and Radar Refraction into account.

It is calculated by adding the 'Land Height' curve, the 'Earth Curvature and Radar Refraction' curve.

Radar Line-of-sight

The Radar Line-of-sight is determined by taking the straight line which:

- Originates at the radiation centre of the radar;
- Has the highest tangent with the Adjusted Land Height Profile;
- Passes through or over the building.

Line-of-sight Ceiling

The Line-of-sight Ceiling is the height, above OSGB36 50m DTM data, of the point at which the Line-of-sight passes the building.

Ceiling Height

The Ceiling Height is the height, above ground level, of the point at which the Line-of-sight passes the building.

Visible Building Height

The Visible Building Height is the vertical distance between the point at which the Line-of-sight passes the building, and the top of the building.

[Visible Building Height] = [Building Height] - [Ceiling Height]

If the Line-of-sight passes below the top of the building then Visible Building Height is positive.

If the Line-of-sight passes above the top of the building then Visible Building Height is negative.

Predominant Blocking Point

The Predominant Blocking Point is defined as the point at which the Radar Line-of-sight is tangential to the Adjusted Land Height Profile.

The Blocking Point is the piece of land that physically prevents or limits the radar's detection of the building development.

Line-of-sight Charts

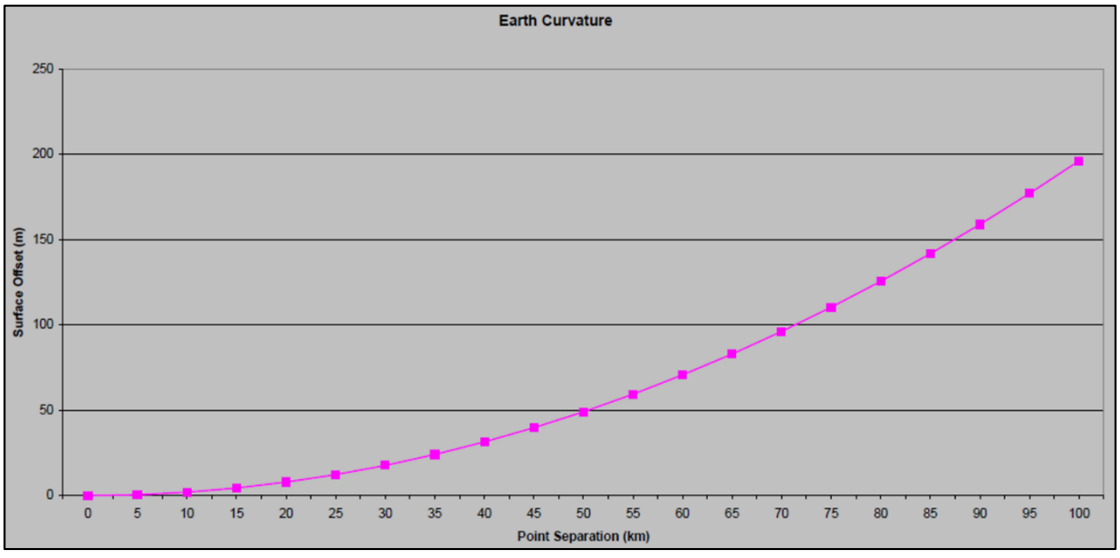
These show the Line-of-sight between the radar and a building.

The horizontal scale shows the distance between the radar and the building in kilometres. 0km at the left hand side corresponds to the radar location. The right hand end of the scale represents the point in the building development.

The vertical scale shows land height in metres. All heights are with reference to OSGB 36 DTM terrain data.

Earth Curvature

The distance between the Earth's surface and the associated chord passing through the Earth's crust increases with point separation. This is shown in the chart on the following page.



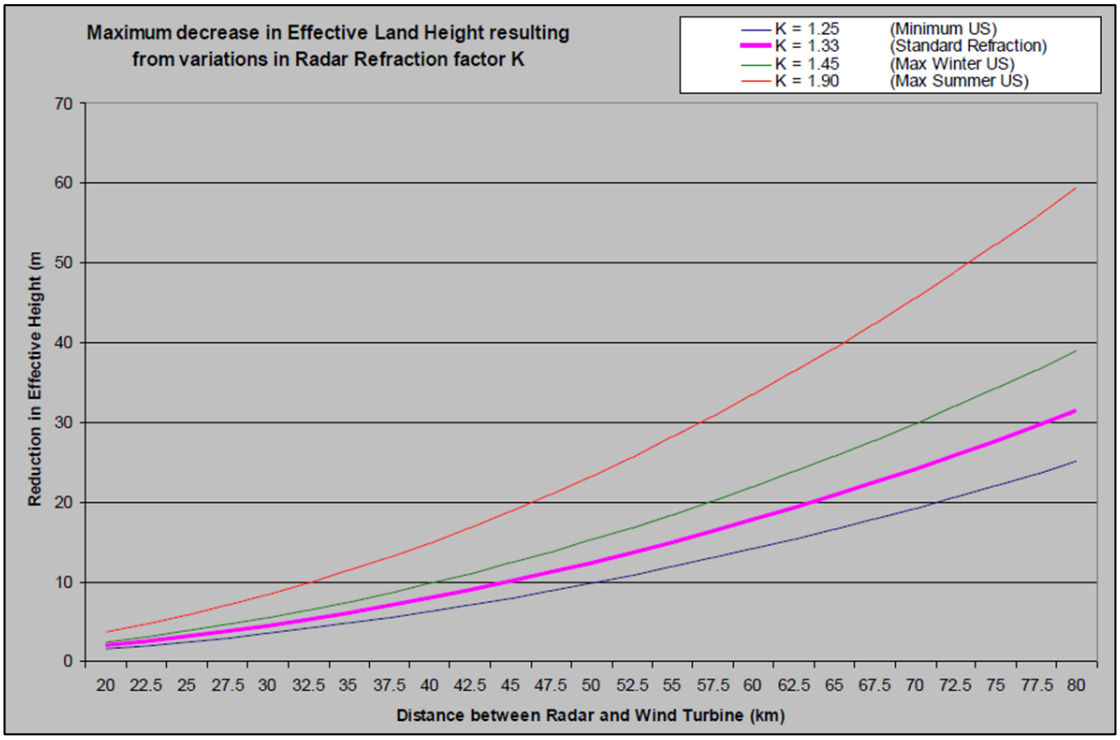
Earth curvature with distance

Effects of variation in Refraction Constant k

The Standard Refraction constant k is 4/3.

Measured values of k in the USA range from 1.25 to 1.90.

The chart below shows the effects of variations in k over a range of distances.



Variations in constant k over a range of distances

APPENDIX C – TERRAIN BASED ANALYSIS

Terrain Based Analysis - Overview

There are many approaches that may be used to undertake terrain based assessments such as radar Line-of-sight profile charts. The overall accuracy of any terrain based assessment is dependent on the following factors:

- Accuracy of co-ordinates and height data for the infrastructure being assessed;
- Resolution and quality of terrain or surface data;
- Choice of algorithm for determining land height from terrain data.

Co-ordinates and height of existing infrastructure may be obtained from the infrastructure owner, custom databases, various forms of mapping or via a site survey. Sometimes the co-ordinate and height data used may be inaccurate because of co-ordinate rounding or confusion between height and altitude. Verification of infrastructure position data makes the results of terrain based assessments more reliable.

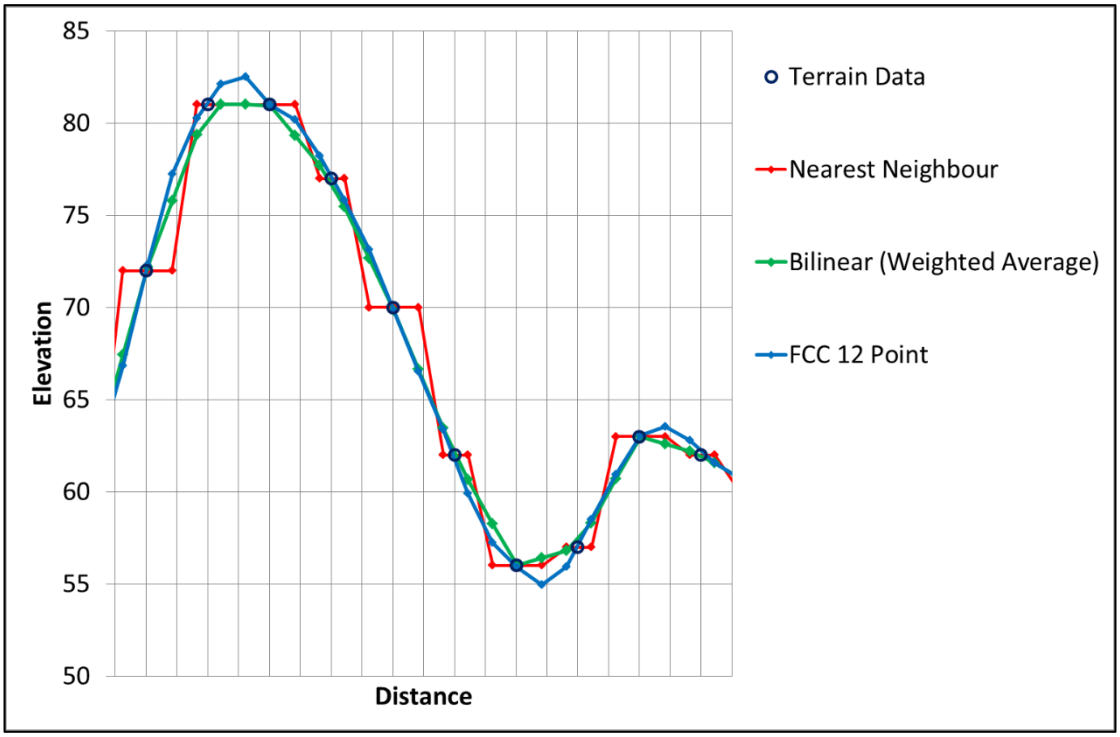
The resolution of digital data is described by its post spacing. Terrain and surface data has a vertical accuracy described by a statistical relationship between database and actual vertical values – a typical rms[1] vertical accuracy being 2 metres.

Terrain data is used to calculate the terrain or surface height at specific locations. There are many processing algorithms for achieving this. These algorithms vary in accuracy and some are more appropriate for certain types of calculations than others. The nearest neighbour algorithm runs quickly and is effective for some applications. A weighted average algorithm is more accurate and generally gives conservative results for radar calculations. A more advanced algorithm using twelve data points is more accurate yet less conservative when determining the likelihood of a radar detecting an obstruction.

The figure on the following page shows an example of how terrain data will be interpreted for an algorithm using the nearest neighbour approach, the weighted average approach and the 12 point approach. The circles represent the data points, which are effectively the raw data and can be considered accurate. The coloured lines show the apparent height that will be calculated by the three algorithms. It can be seen that whilst the 12 point method is in most cases more accurate, it is less conservative than the bilinear weighted average method for Line-of-sight analysis and radar detectability analysis. This is because the weighted average method is more likely to reduce the apparent height of the blocking point, thereby increasing the visibility of the turbine.

Pager Power employs the bilinear weighted average method for its analysis.

[1] Root mean square



Example of Terrain Data Algorithms

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