Reflectivity Report

UTS Central

UTS

Prepared for
UTS

Date: 28 April 2016

Reference: 14001

Revision: 04

Surface Design

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Document control

Revision	Date	Revision details	Author	Sign	Verifier	Sign	Approver	Sign
00	13 /11/2015	First Draft 60% - for comment	AP					
01	27/11/2015	Updated to comments 95%	AP					
02	18/12/2015	Final – DA issue	AP		RM			
03	21/04/2015	Updated DA	AP					
04	28/04/2016	DA – to comments	AP					

Contents

Executive Summary

This reflectivity study has been carried out in order to verify that the façade of the proposed project UTS central will not cause an unacceptable risk of solar reflections causing disability glare to drivers and pedestrians. The City of Sydney requirements are for the external reflectivity of façade elements to be limited to 20%, and this study has been carried out to determine if there are areas of the façade with a requirement for a lower external reflectivity of elements.

The analysis has been carried out based on the architectural drawings provided by FJMT for Development Application.

A total of 9 viewpoints have been selected for this study to represent possible views from drivers and pedestrians of the proposed project. These include viewpoints driving East and West along Broadway, North along Chippendale Way, South along Jones Street and pedestrians crossing the roads of Broadway and Regent Street.

Based on the assessment carried out, it has been determined that on the podium levels with Façade Aspect 245° and 333° there is a requirement to manage the reflectivity beyond the City of Sydney's minimum requirement of 20%.

Reflection of the sun will be controlled through the selection of low reflectivity surfaces and the implementation of glare amelioration devices.

Subject to the review and design development the proposed DA design for UTS is capable of achieving the City of Sydney requirement for glare control.

1. State Significant Development

1.1 Introduction

This report supports a State Significant Development Application (SSDA) submitted to the Department of Planning and Environment pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The SSD Application relates to the Concept Plan Approval for the University of Technology Sydney (UTS) City Campus Broadway Precinct, which was approved in December 2009 (MP08_0116).

The proposed works relate specifically to the UTS Central Project, more specifically the extension of Building 1 (podium) and redevelopment of Building 2 at the City Campus, Broadway Precinct.

As the development has a capital investment value of more than $30 million as an educational establishment, it is identified as State Significant Development under the *State Environmental Planning Policy (State and Regional Development) 2011*, with the Minister for Planning the consent authority for the project.

This report has been prepared having regard to the Secretary's Environmental Assessment Requirements issued for the project.

1.2 Background

UTS recognised the need to upgrade the City Campus back in 2000, and undertook a number of visioning and master planning projects culminating in the *City Campus Masterplan 2020* (BVN, 2008) which provides a framework for refurbishments and new building works across the campus (comprising the Broadway Precinct and other sites in the Sydney CBD) in order to provide improved facilities and to accommodate future expected student and staff growth.

The long term strategic vision for UTS is 'to be one of the world's leading Universities of Technology'.

On 23 December 2009 a critical step in realising UTS's vision and identity for the Broadway Precinct was realised, with approval of the UTS City Campus Broadway Precinct Concept Plan (BPCP) – approved under the former Part 3A of the EP&A Act (MP 08_0116). The approved Concept Plan supports the significant redevelopment of the Broadway Precinct providing for new buildings, alternations and additions to existing buildings, along with associated landscaping and public domain works.

Since approval of the Concept Plan in 2009 UTS has secured the necessary detailed planning approvals and delivered a number of state of the art and iconic learning, research and social facilities across the Broadway Precinct, including:

- Faculty of Engineering and IT Building, designed by Denton Corker Marshall Architects.
- Multi-Purpose Sports Hall.
- Alumni Green, designed by ASPECT Studios Landscape Architects.
- Faculty of Science and Graduate School of Health Building, designed by Durbach Block Jaggers in association with BVN Architecture.
- Library Retrieval System.
- Great Hall and Balcony Room Upgrade, Designed by DRAW Architects in association with Kann Finch Architects.

As part of the staged delivery of the Concept Plan and as expected in its natural evolution, there have been a number of modifications to the Concept Plan. Of note, Modification No 5 to the Concept Plan provides for the complete redevelopment of Building 2, including additional floors above a new podium building.

Overview of Proposed Development

This SSD Application seeks approval for the following components of the development:

- Site preparation works, including demolition and clearance of existing Building 2 down to approximately ground level and associated tree removal;
- Retention and re-use of existing basement Level 1 and Level 2;
- Construction and use of a new podium building fronting Broadway (Building 1 extension and new Building 2);
- Construction and use of new floors above new Building 2 podium;
- Public domain improvements surrounding the site;
- Landscaping works to roof levels;
- Retention of existing vehicle access and parking arrangements and
- Extension and augmentation of physical infrastructure / utilities as required.

The new floor space will accommodate a range of educational and ancillary educational uses, such as:

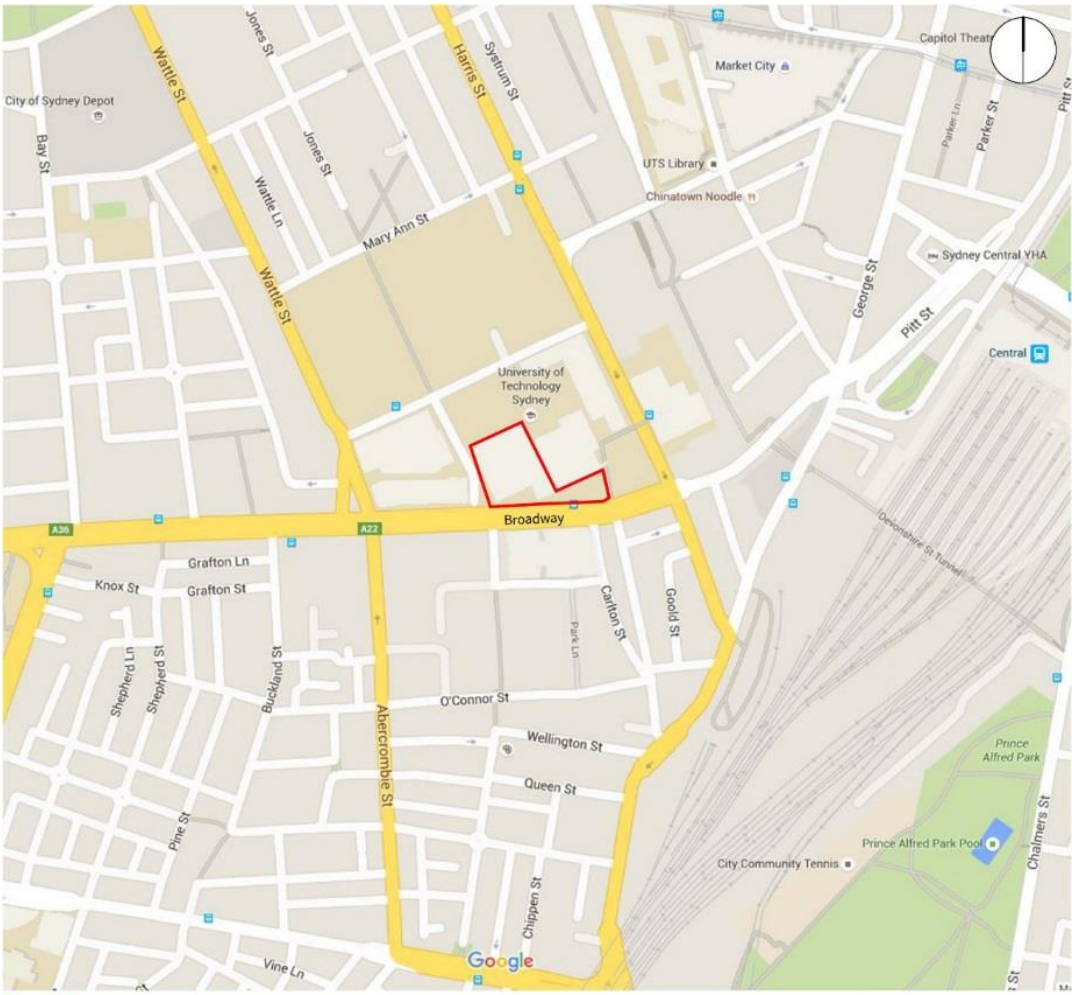
- Library
- Research
- Teaching Space
- Informal Learning Space
- Student Centre
- Student Union Spaces
- Food and Beverage Outlets
- Academic (including Faculty space)

A more detailed and comprehensive description of the proposal is contained in the Environmental Impact Statement (EIS) prepared by JBA.

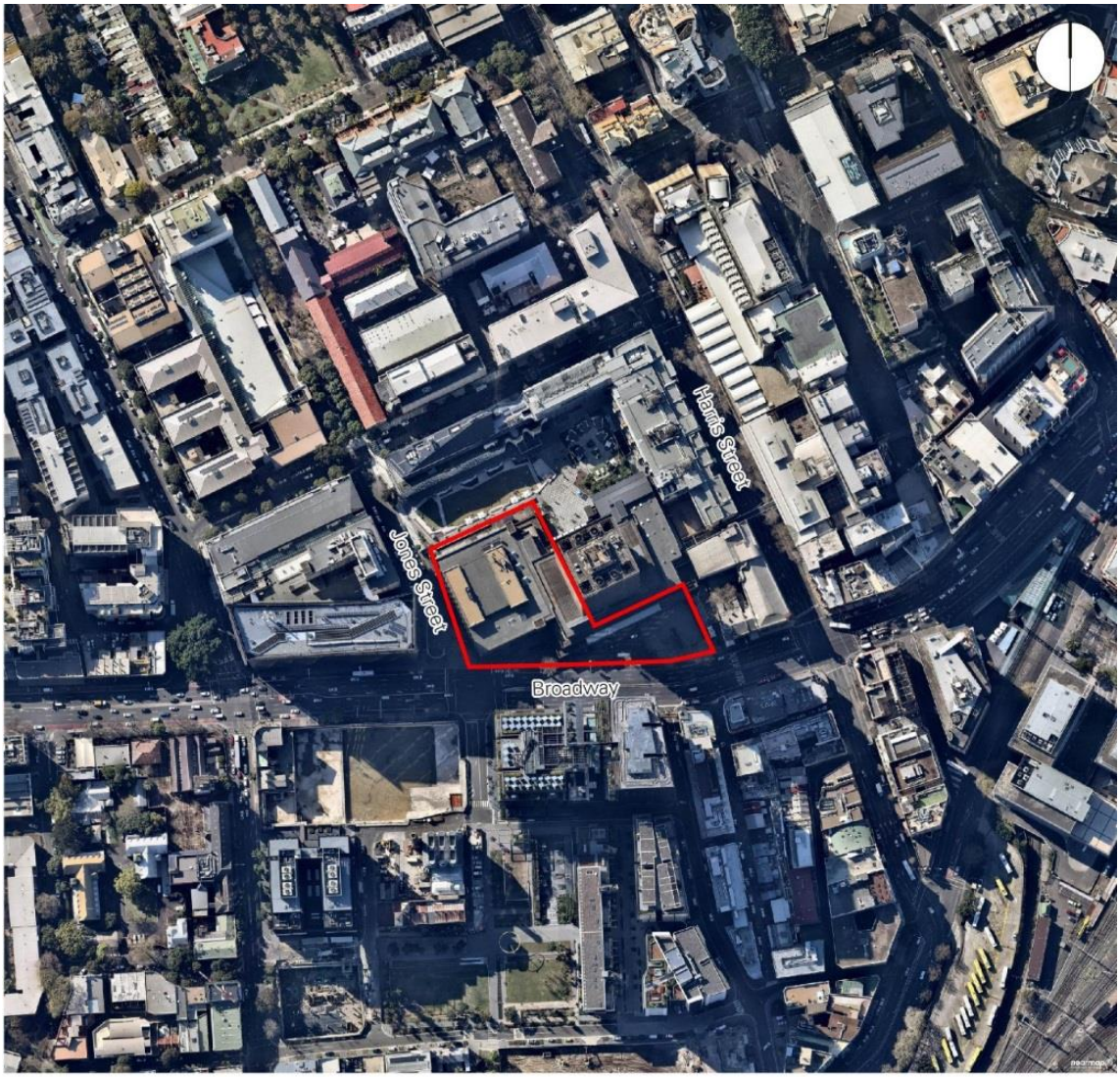
1.3 The site

The Broadway Precinct of the UTS City Campus is located on the southern edge of the Sydney Central Business District with frontages to Broadway, and Thomas, Wattle and Harris Streets (see **Figure 1**). Central station is located less than 500m to the east.

More specifically the UTS Central project site relates to Building 1 (excluding the Building 1 tower) and Building 2 of the Broadway Precinct, refer to **Figure 2**.


Capitol Theatre
Market City
City of Sydney Depot
Bay St
Wattle St
Jones St
Harris St
Syatrum St
UTS Library
Chinatown Noodle
Parker St
Mary Ann St
Sydney Central YHA
George St
Pitt St
Central
University of Technology Sydney
Broadway
A36
A22
Grafton Ln
Grafton St
Knox St
Shepherd Ln
Shepherd St
Buckland St
Carlton St
Gould St
Park Ln
O'Connor St
Wellington St
Queen St
Abercrombie St
Pine St
Chippen St
Vine Ln
Prince Alfred Park
Prince Alfred Park Pool
City Community Tennis
Chalmers St
Google

The Site



The Site

2. Introduction

2.1 Purpose of the Report

This report details the results of a reflectivity study that aims to identify the potential for adverse reflected solar glare that may affect drivers and pedestrians within the proximity of the UTS Central development. This is a safety issue and is required under the City of Sydney requirements for design of new buildings. The City of Sydney has a requirement that the external reflectivity of materials used on the facades of new buildings does not exceed 20%. The proposed building is to comply with this requirement.

This report should be read in conjunction with the DA Architectural documents prepared by FJMT.

2.2 Site Location

The site has been assessed to determine appropriate viewpoints where drivers (red), and pedestrians when they are crossing the road (blue), are able to see the building façade in their direct line of vision.

It has been assessed that the building is visible to drivers from the following locations:

- Travelling in West along Broadway (VP1)
- Travelling in West along Broadway (VP2)
- Travelling in North along Chippendale way (VP3)
- Travelling in East along Broadway (VP4)
- Travelling in East along Broadway (VP5)
- Travelling in South along Jones Street (VP6)

It is also directly visible to pedestrians crossing roads at the following locations:

- Crossing the road of Regent Street (VP7)
- Cross Broadway travelling North (VP8)

Figure 1 - Satellite Image with Viewpoints[1]

[1] Image from Google Maps

2.3 Site Orientation

The UTS central redevelopment is a building with a complex geometry. The aspects of each orientation of the façade changes considerably with the height of the building. For calculations simplification the building has been split 3 zones; podium, L8-L13 and L13-Roof.

The building is 18 storeys tall, with the podium running from ground floor to level 7 and the tower extending to level 18.

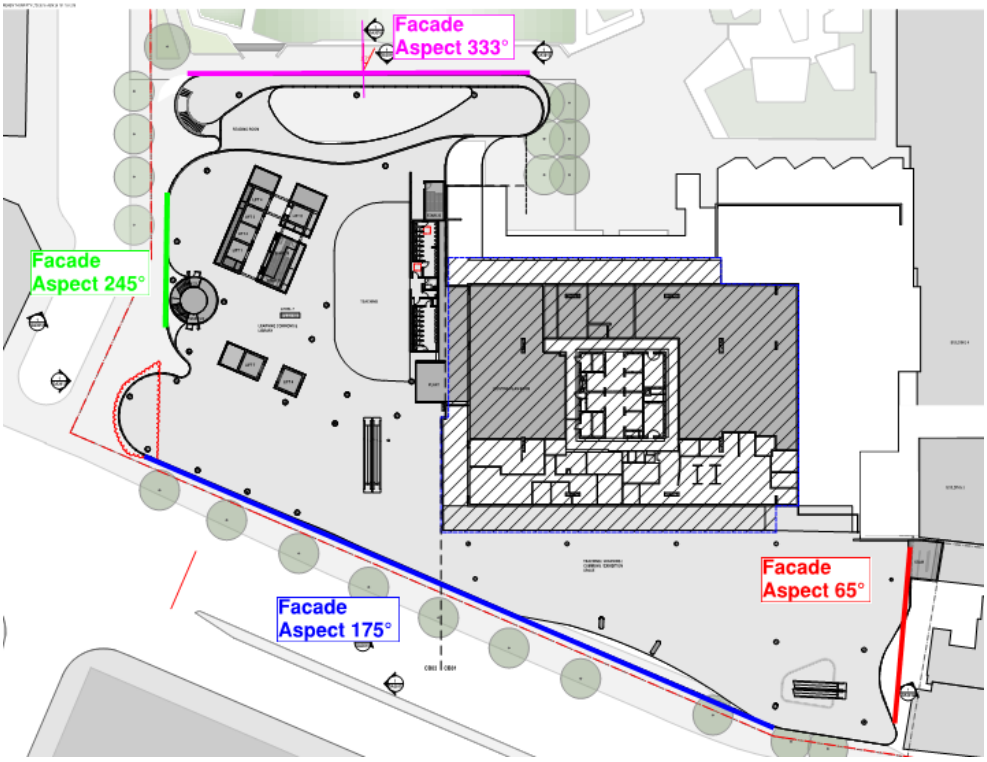


Figure 2 –L1-L7 Podium Plan with Orientation Aspect

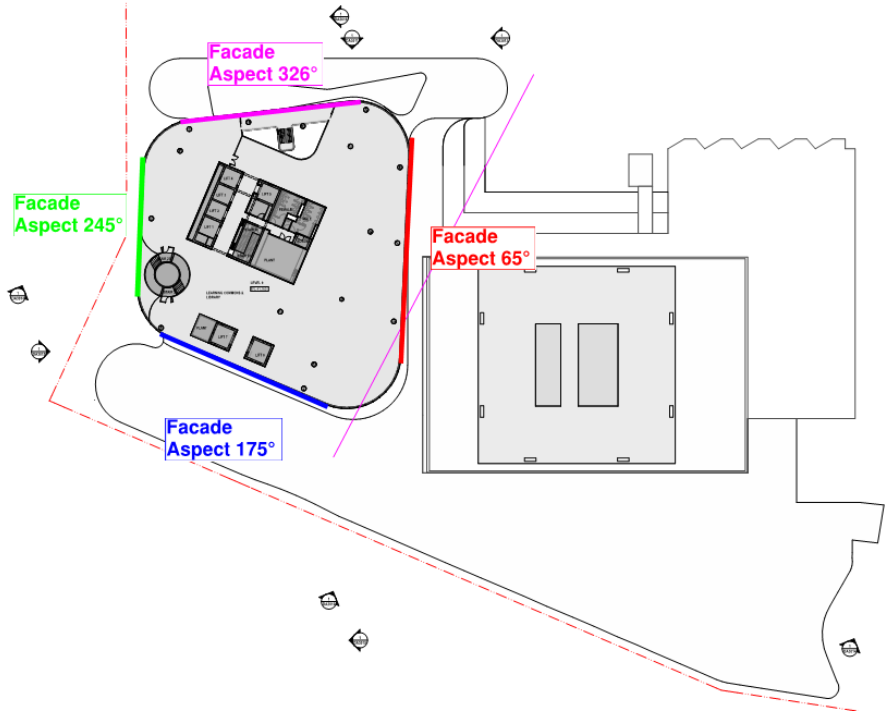


Figure 3 – L8-13 Tower Plan with Orientation Aspect

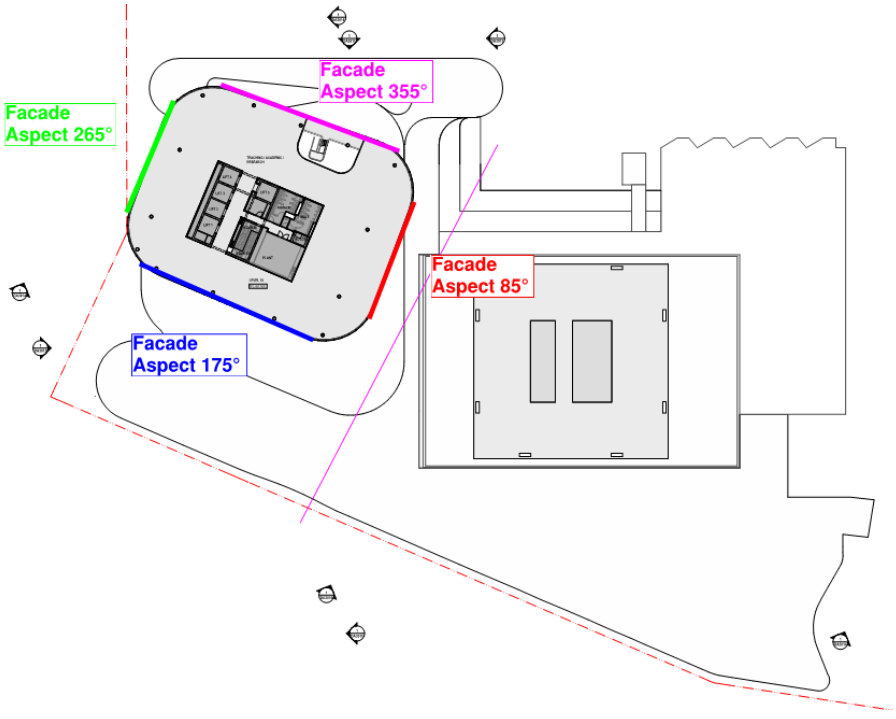


Figure 4 – L 13-18 Tower Plan with Orientation Aspect

2.4 Stereographic Sun Chart

The position of the sun in the sky throughout the year varies depending on the latitude of the location of assessment. A stereographic sun chart is a two dimensional representation of this path of the sun for a particular line of latitude.

This chart is used in order to determine the location of a virtual reflected sun in accordance with the Hassall methodology in order to assess the potential for glare. Refer to Section 2 of this report for more detailed information on the assessment methodology

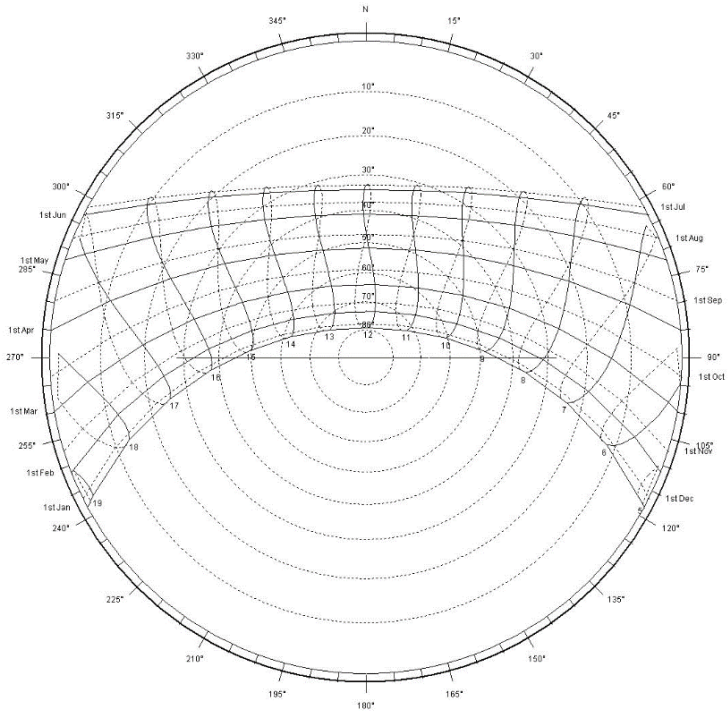


Figure 5 – Stereographic Sun Chart for Sydney (34 degree latitude)

3. Assessment Methodology

3.1 Analysis Philosophy

The glare assessment has been carried out as per the methodology outlined in the technical bulletin "Reflectivity: Dealing with Rogue Solar Reflections" written by David Hassall from the Faculty of Architecture at the University of New South Wales.

This methodology defines a glare (I_v) limit of 500 candelas/m^2, calculated to the Holladay formula, to which a driver can be exposed without causing disability.

Viewpoints have been defined from which it is expected that either drivers or pedestrians where they are crossing the road, are able to see the building. A stereographic sun path diagram and the building geometry are then used to determine whether a viewpoint will be subject to the reflected sun during the year.

A glare protractor, oriented in the direction of drivers or pedestrians as appropriate, is used to determine the glare based on the reflectivity of the surface and the apparent angle of viewing.

3.2 Virtual Sun Location

The virtual suns location is determined with the stereographic sun chart for the project location.

This is completed by plotting the virtual sun on the stereographic sun chart based on the orientation of the façade. The apparent reflective surface of the façade is plotted based on the bounding horizontal and vertical angles from the viewpoint.

3.3 Glare Assessment

In order to allow assessment of buildings for glare David Hassall has developed a glare protractor that provides a diagrammatic limit of 500 candelas/m^2 based on viewing angle and inclination and reflectivity of the viewing surface. This glare protractor is shown in Figure 7 and is used where the stereographic sun path indicates that there is glare to a particular viewpoint.

A brief description of the calculation of the glare (equivalent veiling luminance) is provided below for reference. The glare protractor has thereafter been used in this assessment.

The equivalent veiling luminance (I_v) is calculated based on the Holladay formula (1), which defines the illumination of a viewer's eye based on a calculated illuminance perpendicular to the surface (EG) and a factor based on the angle of viewing (θ).

$$I_v = 10 \times EG \div \theta^2 \quad (1)$$

The angle of viewing (θ) is based on the angle between the direct line of sight and the glare source (α) and the inclination between a viewing normal and the glare source (β). This is calculated with trigonometry based on Equation 2 below and is shown diagrammatically in Figure 6.

$$\theta = ATAN \times [\sqrt{\{\tan^2(\beta) + \sin^2(\alpha)\}} \div \cos(\alpha)] \quad (2)$$

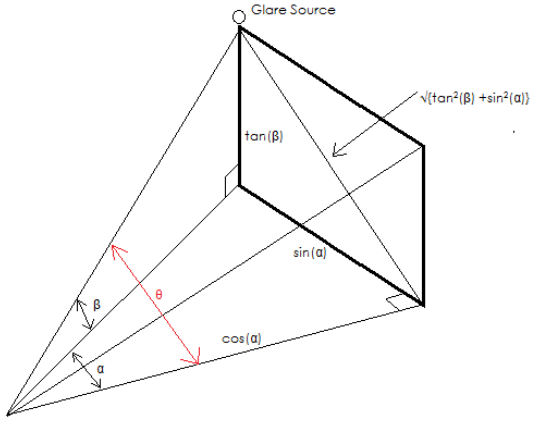


Figure 6 – Diagrammatic Angle of Viewing Calculation

The illumination of the viewer's eye normal to the light source (EG) is calculated based on the solar illumination (E), the reflectivity of the surface (R) and the angle of viewing (θ) calculated in Equation 2. The solar illumination is calculated in Equation 4 based on the solar power (W), which is dependent on the inclination of the virtual sun (β) and the luminance efficacy (l_e).

$$EG = E \times R \times \cos(\theta) \quad (3)$$

$$E = W \times l_e \quad (4)$$

The solar power is determined as 50 watts per degree up to 10 degrees and 15 watts per degree thereafter.

The luminance efficacy is 90 lumens/watt at 7.5° and 117 lumens/watt at 25° and is interpolated for other angles.

The glare protractor by Hassall joins points at incremental reflectivity (iso-glare loops) with varying a and β values in order to set a limit where the equivalent veiling luminance is limited to 500 candelas/m^2.

By overlaying the glare protractor on a photo or computer generated image in the direction of viewing and aligning the verticals with the building it is possible to graphically determine the maximum reflectivity to not cause disability glare.

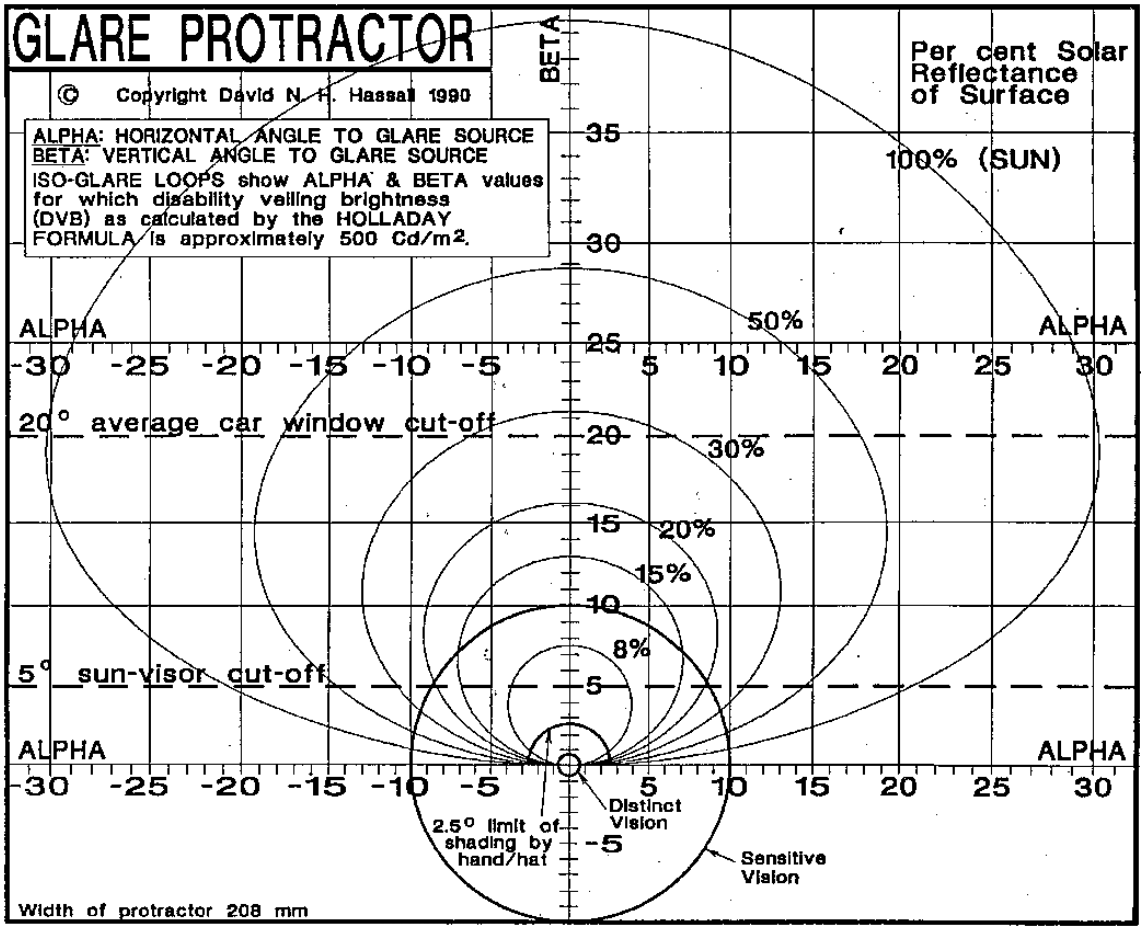


Figure 7 – Glare Protractor[2]

[2] "Reflectivity: Dealing with Rogue Solar Reflections" – David Hassall

4. Results

4.1 General

The aspects of the facades pertaining to each view point has been assessed

Where it is identified that there is reflected image, the glare protractor is applied in order to determine the maximum reflectivity allowable on the façade surface to achieve a maximum equivalent veiling luminance of 500 candelas/m^2.

Detailed results have been included as part of Appendix A. A summary of these results is provided in this section.

4.2 Viewpoint 1

Viewpoint 1 has been taken at a distance of 50m from the South-East of the building. It is taken from the viewpoint of a driver travelling west along Broadway.

The path of the reflected sun has been plotted for the 65° and 85° façade aspect that is visible from this viewpoint, refer to Appendix A.

It was determined that reflected image of the sun from the building does not impact the driver on the road. The reflected image of the sun will be outside the area where a façade surface with 20% reflectivity would cause the equivalent veiling luminance to exceed 500 candelas/m^2. No further actioned required.

4.3 Viewpoint 2

Viewpoint 2 has been taken at a distance of 35m from the South of the building. It is taken from the viewpoint of a driver travelling west along the Broadway.

The path of the reflected sun has been plotted for the 175° and 65° façade aspect that is visible from this viewpoint, refer to Appendix A.

It was determined that reflected image of the sun from the building does not impact the driver on the road. The reflected image of the sun will be outside the area where a façade surface with 20% reflectivity would cause the equivalent veiling luminance to exceed 500 candelas/m^2. No further action required

4.4 Viewpoint 3

Viewpoint 3 has been taken at a distance of 38m from the south of the building. It is taken from the viewpoint of a driver travelling north along Chippendale Way.

The path of the reflected sun has been plotted for the 175° façade aspect that is visible from this viewpoint, refer to Appendix A.

It was determined that reflected image of the sun from the building does not impact the driver on the road. The reflected image of the sun will be outside the area where a façade surface with 20% reflectivity would cause the equivalent veiling luminance to exceed 500 candelas/m^2. No further action required

There is a risk that the 245° façade will cause disability glare to a driver travelling along Chippendale way. The visor cut off for cars is 5%, all of the façade is above this level. No further action required.

4.5 Viewpoint 4

Viewpoint 4 has been taken at a distance of 40m from the south-west of the building. It is taken from the viewpoint of a driver travelling east along Broadway.

The path of the reflected sun has been plotted for the 175° , 245° and 265° façade aspect that is visible from this viewpoint, refer to Appendix A.

It was determined that reflected image of the sun from the building does not impact the driver on the road. The reflected image of the sun will be outside the area where a façade surface with 20% reflectivity would cause the equivalent veiling luminance to exceed 500 candelas/m^2. No further action required

4.6 Viewpoint 5

Viewpoint 5 has been taken at a distance of 200m from the South-West apex of the building. It is taken from the point of view of a vehicle travelling East down Broadway. The view is obscured by the presence of the UTS Faculty of Engineering and IT building. No further action required.

4.7 View Point 6

Viewpoint 6 has been taken at a distance of 81m from the north-east of the building. It is taken from the viewpoint of a driver travelling south along Jones Street.

The path of the reflected sun has been plotted for the 326°, 333° and 355° façade aspects that are visible from this viewpoint, refer to Appendix A.

There is a reflected image of the sun that reaches Viewpoint 6 from Façade Aspect 326°. For a driver travelling along Jones Street at 13:00 till 15:00 between July and August there is a reflected image of the façade aspect 326° will reach the pedestrian. The reflectivity of the lower levels of the Northern façade will need to have an external reflectivity of less than 15% to prevent disability glare during these times.

4.8 View Point 7

Viewpoint 7 has been taken at a distance of 81m from the north-east of the building. It is taken from the viewpoint of a pedestrian crossing the Regent Street.

The path of the reflected sun has been plotted for the 65° and 355° façade aspects that are visible from this viewpoint, refer to Appendix A.

It was determined that reflected image of the sun from the building does not impact the pedestrian on the road. The reflected image of the sun will be outside the area where a façade surface with 20% reflectivity would cause the equivalent veiling luminance to exceed 500 candelas/m^2.

No further action required.

4.9 View Point 8

Viewpoint 8 has been taken at a distance of 38m from the south of the building. It is taken from the viewpoint of a pedestrian crossing the Broadway near Chippendale Street.

The path of the reflected sun has been plotted for the 245° and 175° façade aspects that are visible from this viewpoint, refer to Appendix A.

There is a reflected image of the sun that reaches Viewpoint 8 from Façade Aspect 246°. For a pedestrian crossing the road at 3:45pm-5:00pm in the months of July and August there is a reflected image of the façade aspect 245° will reach the pedestrian. The reflectivity of the lower levels of the western façade will need to have an external reflectivity of less than 15% to prevent disability glare during these times.

5. Conclusion

This reflectivity study has been carried out in order to address the potential for disability glare to affect pedestrians and drivers caused by UTS Central development. This report details additional requirements, beyond the City of Sydney requirement for the external reflectivity of all façade materials to be less than 20%, for the project façade in order to prevent the occurrence of disability glare.

The analysis has been completed based on the architectural drawings provided FJMT for DA.

The glare assessment has been carried out as per the methodology outlined in the technical bulletin "Reflectivity: Dealing with Rogue Solar Reflections" written by David Hassall.

A total of 8 viewpoints have been selected for this study to represent possible views from drivers and pedestrians of the proposed project. These include viewpoints driving East and West along Broadway, North along Chippendale Way, South along Jones Street and pedestrians crossing the roads of Broadway and Regent Street.

Reflection of the sun will be controlled through the selection of low reflectivity surfaces and glazing to the facade.

Based on the assessment carried out it has been determined that on the podium levels with Façade Aspect 245° and 333° there is a requirement to manage the reflectivity, beyond the City of Sydney's minimum requirement of 20%.

Overall, subject to the design development and implementation of glare amelioration devices the proposed DA design for UTS is capable of achieving the City of Sydney requirement for glare control.

Appendix A

Appendix A – Detailed Results

Viewpoint 1

Viewpoint 1 has been taken at a distance of 81m from the South-East apex of the building. It is taken from the viewpoint of a driver travelling west along Broadway. The higher portion of the tower is obscured from the view of the driver by the existing UTS tower.

On Figure 8 below black, blue and pink lines have been drawn to represent the bearing angles to the two extreme façade aspects of the podium and tower respectively. The red arrow indicates the direction of travel and viewing.

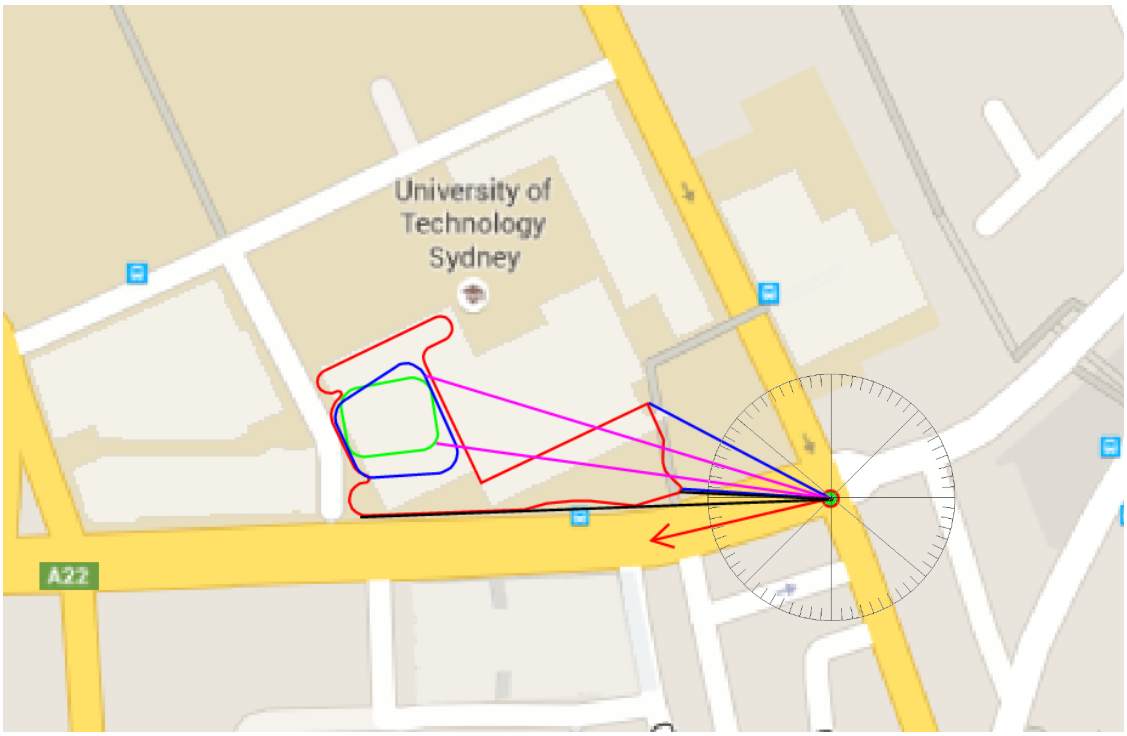


Figure 8 – Viewpoint 1 Broadway (Façade Aspect 65° and 85°)[3]

The vertical bearing angles have been calculated for the building

B_{podium} = $\tan^{-1}(30m \div 65m)$
= 24.5°

B_{tower1} = $\tan^{-1}(57m \div 150m)$
= 20.8°

B_{tower2} = $\tan^{-1}(73m \div 150m)$
= 25.9°

Viewing Direction		Vertical Bearing Angle		Horizontal Bearing Angle (0° at North)					
				Façade Aspect 65°		Façade Aspect 85°		Façade Aspect 175°	
		Lower Bound	Upper Bound	Left Bound	Right Bound	Right Bound	Left Bound	Right Bound	Left Bound
Podium	255°	0°	24.5°	270°	300°	NA	NA	265°	270°
Tower 2	255°	24.5°	25.9°	NA	NA	280°	290°	N/A	N/A

These bearing angles have been plotted on the reflected sun path diagrams in Figure 9.

[3] Google Maps

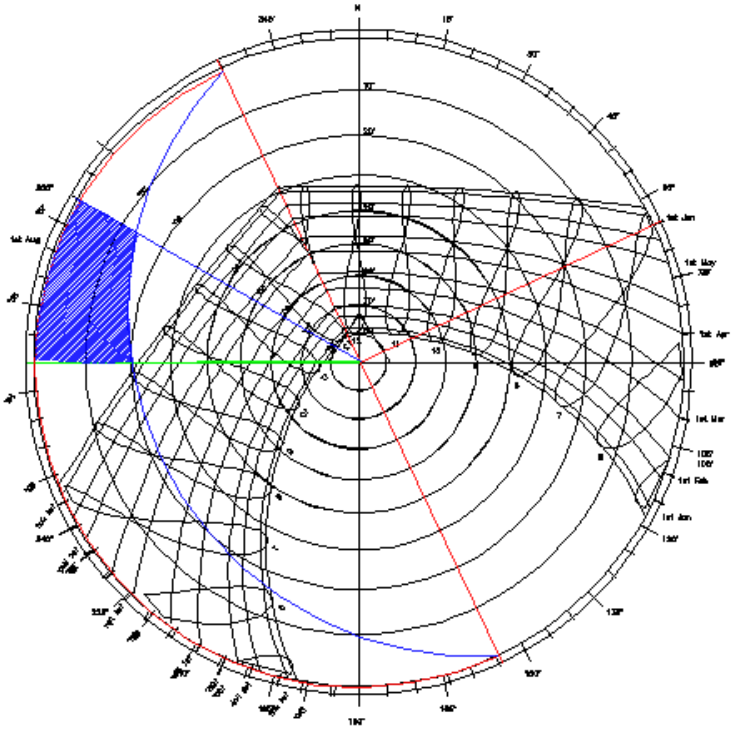


Figure 9 – 65° Façade Aspect Reflected Virtual Sun from Viewpoint 1

There is no reflected image of the sun that reaches Viewpoint 1 from Façade Aspect 65° of the building.

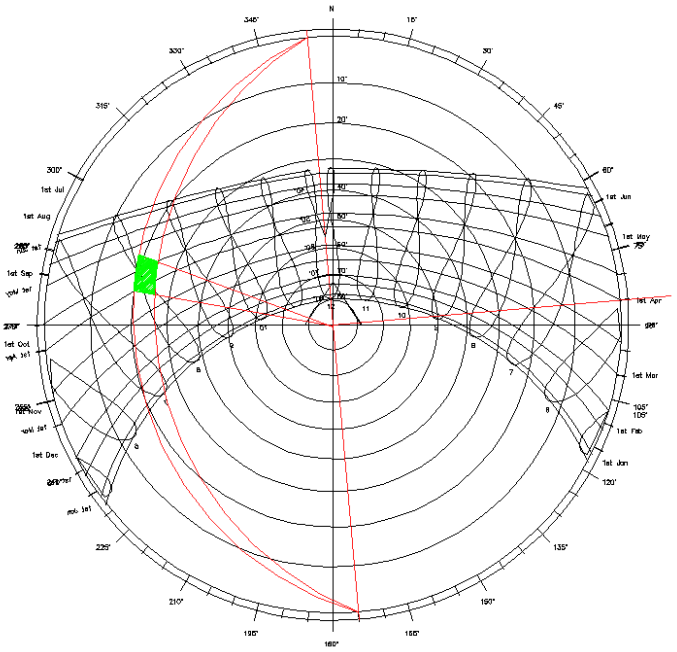


Figure 10 – 85° Façade Aspect Reflected Virtual Sun from Viewpoint 1

There is a reflected image that reaches Viewpoint 2 from Façade Aspect 85° of the building between 7:30am – 8:30am from late April to May. Between In order to assess the façade a photo has been taken and the glare protractor has been applied at scale has been aligned with the top of the building.

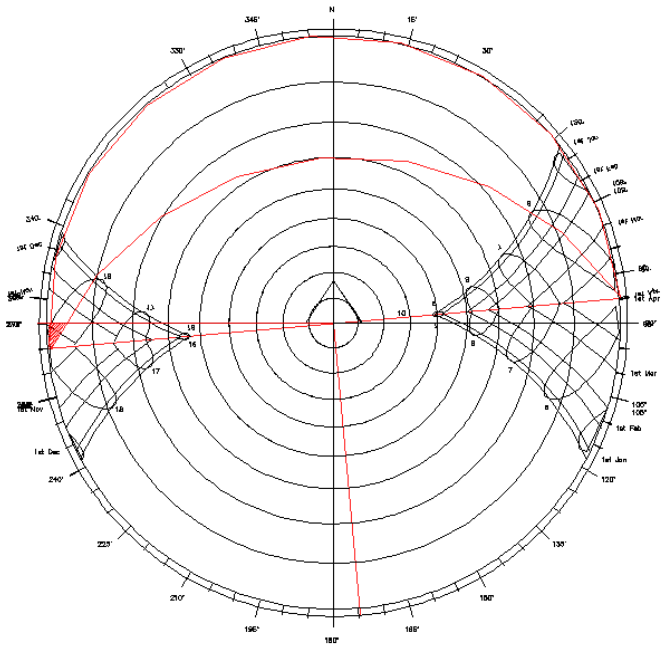
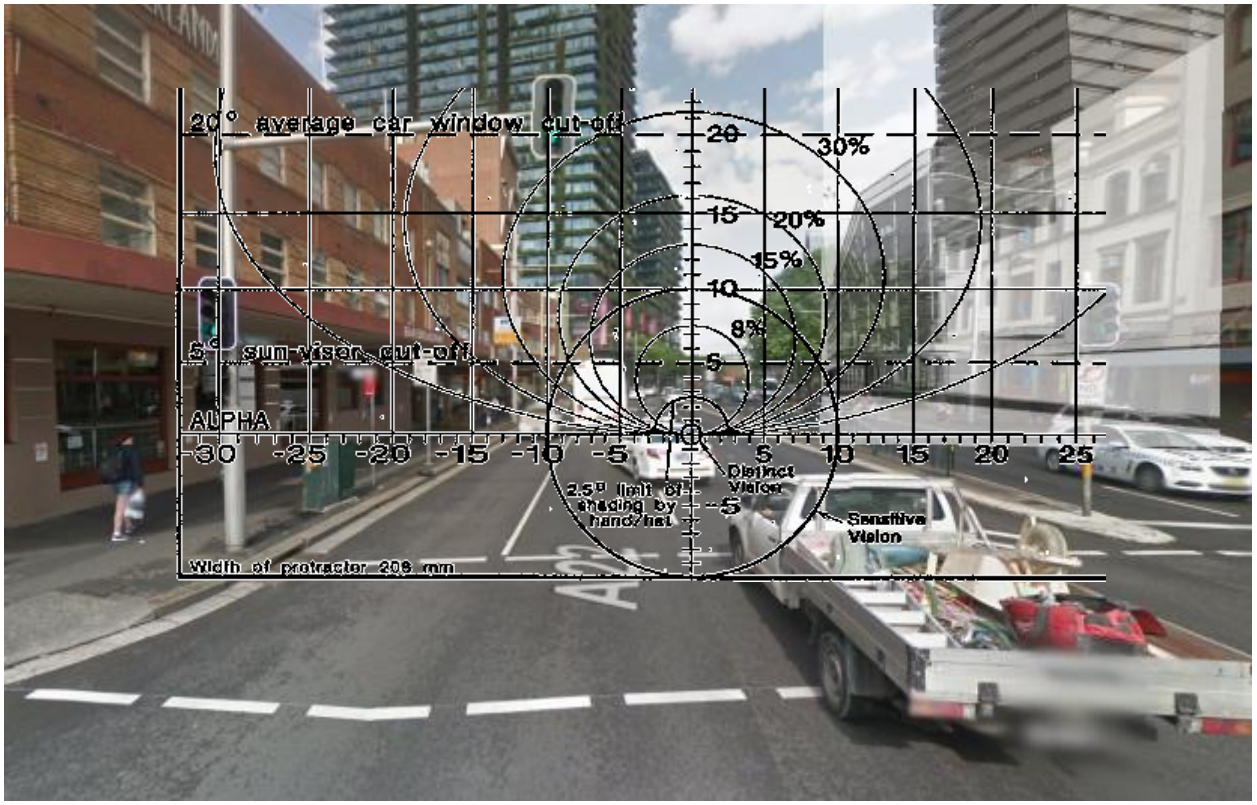


Figure 11 - 175° Façade Aspect Reflected Virtual Sun from Viewpoint 1

There is a reflected image that reaches Viewpoint 2 from Façade Aspect 175° of the building between 18:00 – 19:00 from late October to early November. In order to assess the façade a photo has been taken and the glare protractor has been applied at scale has been aligned with the top of the building.



The proposed development, viewed from the direction of travel, is outside 20% reflectivity required by the City of Sydney and therefore no additional measures to reduce glare are required.

Viewpoint 2

Viewpoint 2 has been taken at a distance of 30m from the South East aspect of the podium. It is taken from the viewpoint of a driver travelling west along Broadway. From view point one the façade aspect 180° has been analysed. From the perspective of a driver travelling down Broadway the tower façade is obscured by the podium

On Figure 12 below the black, blue and pink lines have been drawn to represent the bearing angles of the podium, with the red arrow indicating the direction of travel and viewing.

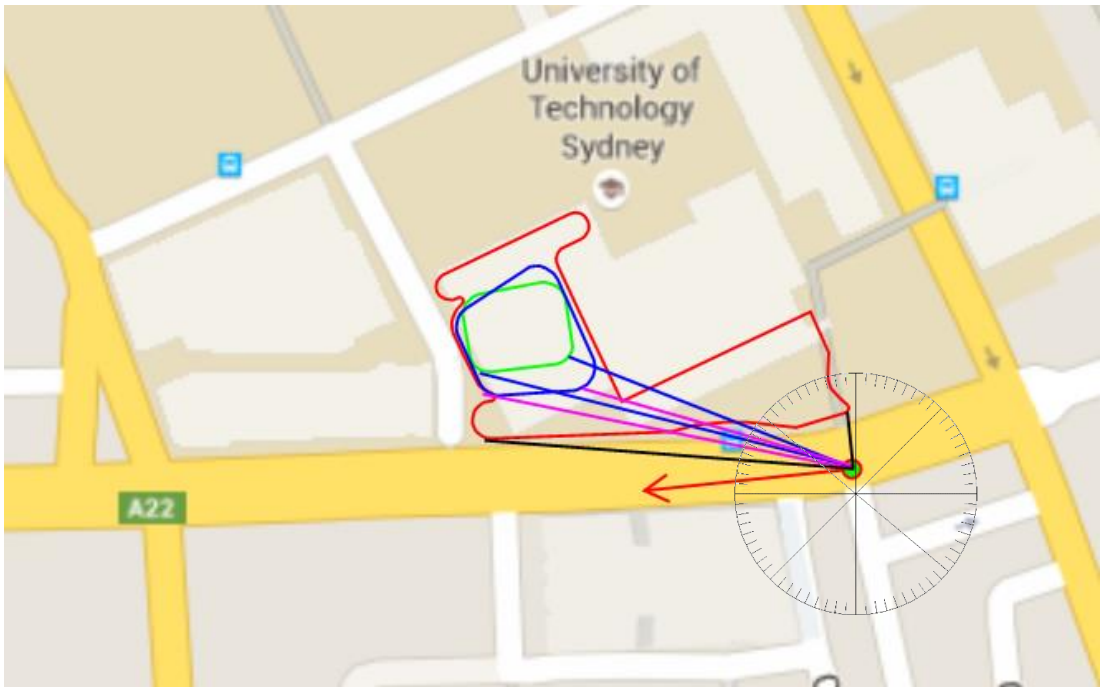


Figure 12 – Viewpoint 2 horizontal bearing angles[4]

The vertical bearing angles have been calculated for the development.

B_{podium} = $\tan^{-1}(32m \div 61m)$
= 27.65°

B_{Tower1} = $\tan^{-1}(57m \div 73m)$
= 37.9°

B_{Tower2} = $\tan^{-1}(73m \div 95m)$
= 36.68°

From the angle of incidence from the point of view of the driver, the top of the tower is obscured by the façade of the podium and tower below.

Viewing Direction		**Vertical Bearing Angle**		**Horizontal Bearing Angle (0° at North)**	
				Façade Aspect 175°	
		Lower Bound	Upper Bound	Left Bound	Right Bound
Podium	26°	0°	27.31°	280°	350°
Tower1	265°	27.65°	37.9°	290°	310°
Tower2	265°	NA	NA	295°	315°

These bearing angles have been plotted on the reflected sun path diagrams in Figure 13 and Figure 14 below.

[4] Google Maps

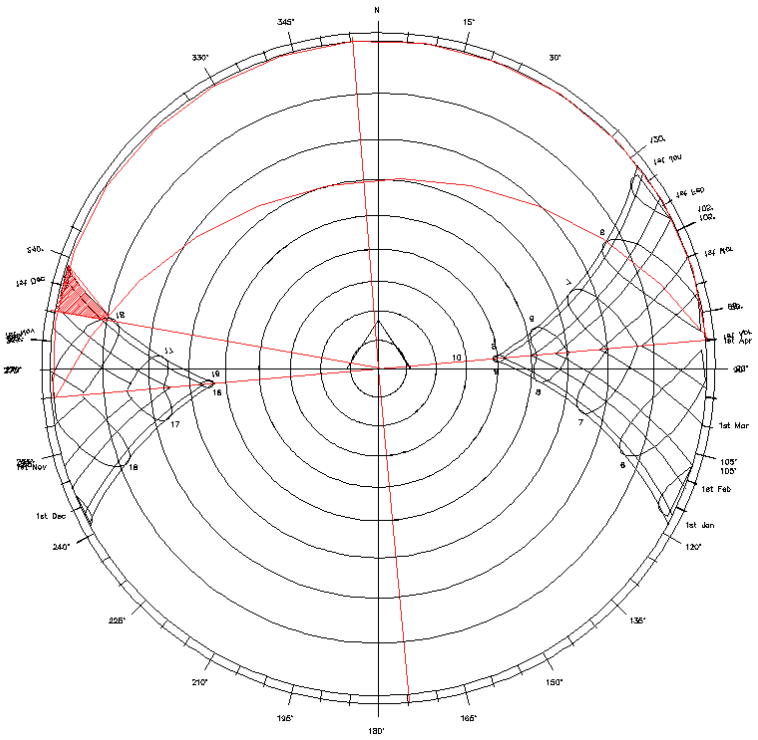


Figure 13 – 175° Façade Aspect Reflected Virtual Sun from Viewpoint 2

There is a reflected image that reaches Viewpoint 2 from Façade Aspect 175° of the building between 18:00 and 19:00 in late December. In order to assess the façade a photo has been taken and the glare protractor has been applied at scale has been aligned with the top of the building.

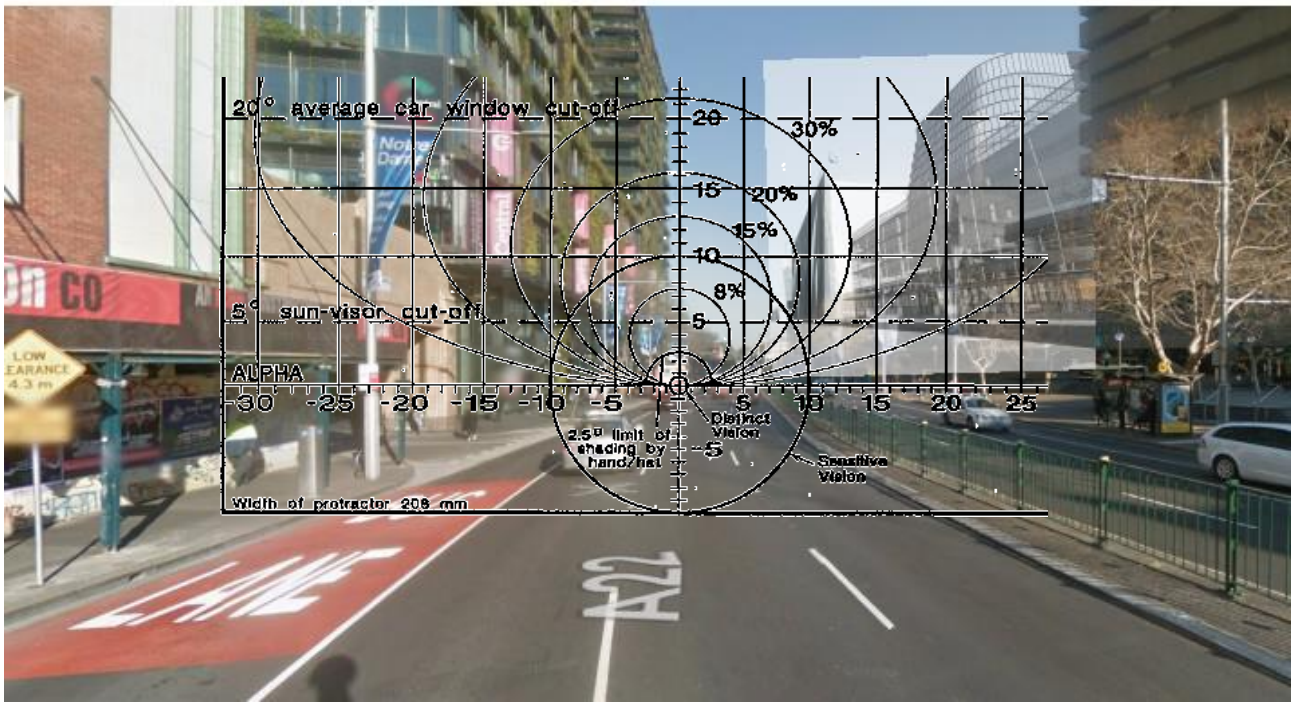


Figure 14 – 175° Façade Aspect Reflected Virtual Sun from Viewpoint 2

The proposed development, viewed from the direction of travel, is outside 20% reflectivity required by the City of Sydney and therefore no additional measures to reduce glare are required.

Viewpoint 3

Viewpoint 3 has been taken at a distance of 30m from the South façade. It is taken from the viewpoint of a driver travelling North from the Chippendale way onto Broadway. The higher portion of the tower is deemed not to effect a vehicle as it is above the angle in the glare protractor.

On Figure 15 and 16 below black and pink lines have been drawn to represent the bearing angles to extreme aspects of the facade. The red arrow indicates the direction of travel and viewing.

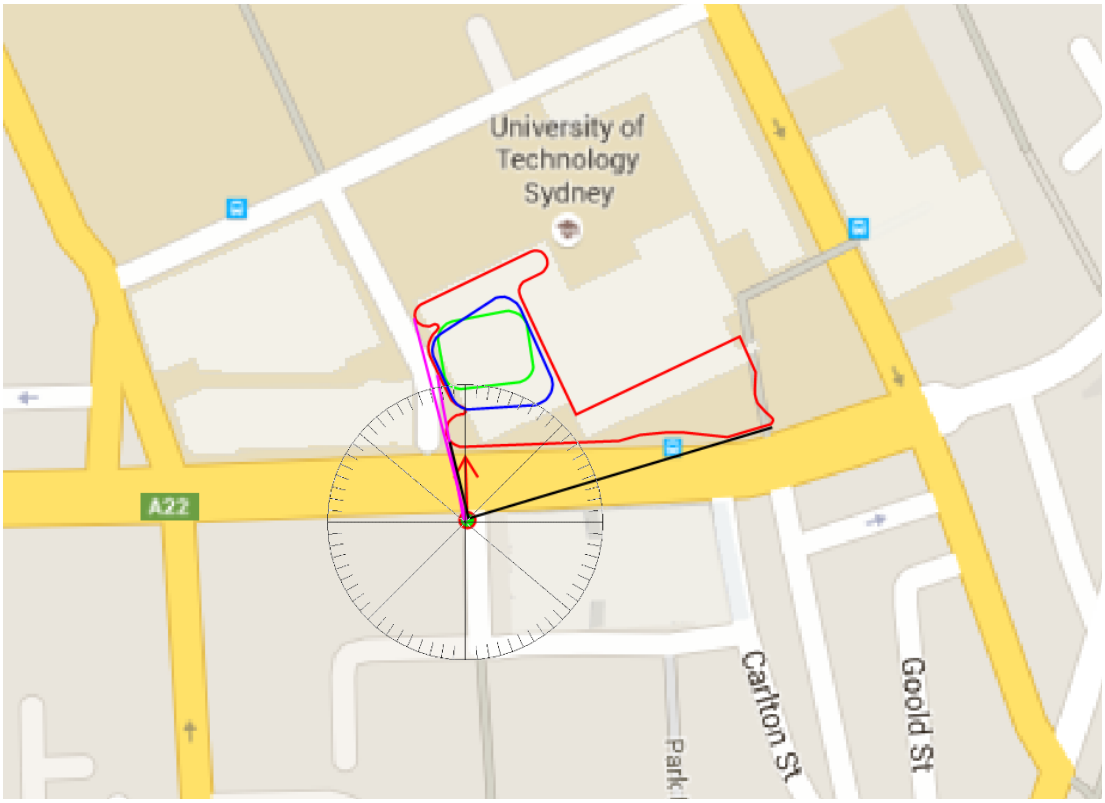


Figure 15 – Viewpoint 3 – Façade Aspect 180° horizontal bearing angles[5]

The vertical bearing angles have been calculated for the Building

B_{podium} = $\tan^{-1}(32m \div 35.9m)$
= 39.11°

$B_{podium2}$ = $\tan^{-1}(50m \div 75m)$
= 21.11°

B_{Tower} = $\tan^{-1}(73m \div 55m)$
= 47.1°

Viewing Direction		Vertical Bearing Angle		Horizontal Bearing Angle (0° at North)			
				Façade Aspect 175°		Façade Aspect 245°	
		Lower Bound	Upper Bound	Left Bound	Right Bound	Left Bound	Right Bound
Podium	355°	0°	39.11°	350°	70°	345°	350°

These bearing angles have been plotted on the reflected sun path diagrams and below.

[5] Google Maps

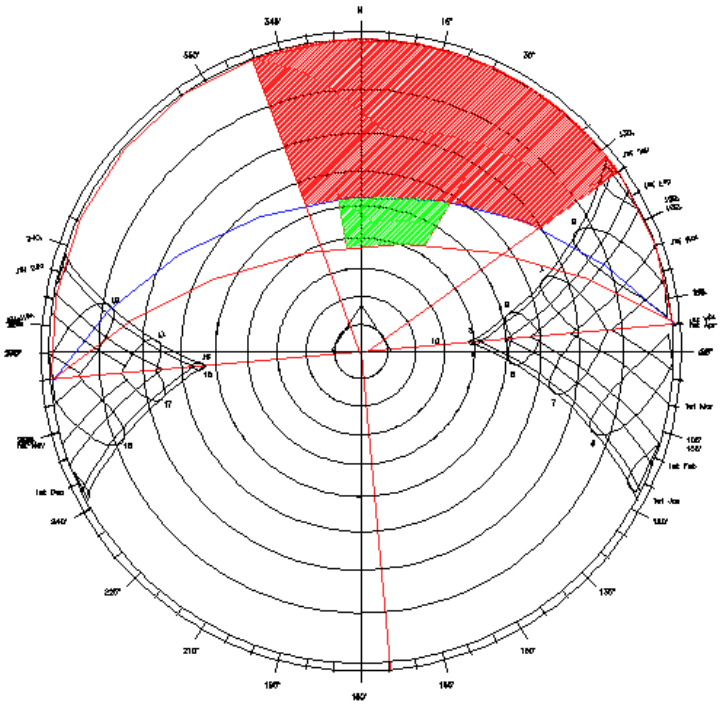


Figure 16 – 175° Façade Aspect Reflected Virtual Sun from Viewpoint 3

There is a reflected image of the sun that reaches viewpoint 3 from façade Aspect 175° at 5:30am in early January. In order to assess the façade a photo has been taken and overlayed with a rendering of the UTS façade (FJMT), a protractor is then applied at scale.

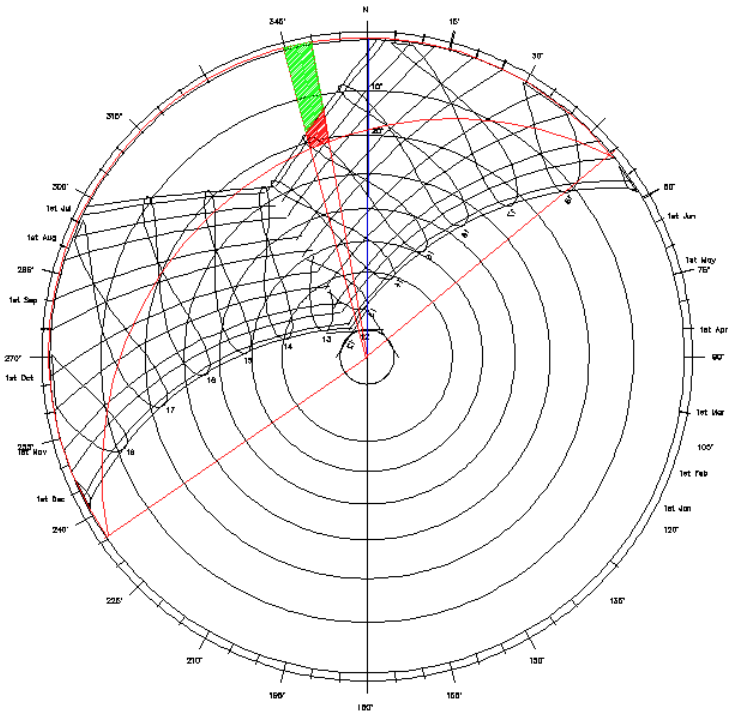


Figure 17 245° Façade Aspect Reflected Virtual Sun from Viewpoint 3

There is a reflected image of the sun that reaches viewpoint 3 from façade Aspect 245° at approximately 3pm from July to August. In order to assess the façade a photo has been taken and overlayed with a rendering of the UTS façade (FJMT), a protractor is then applied at scale.

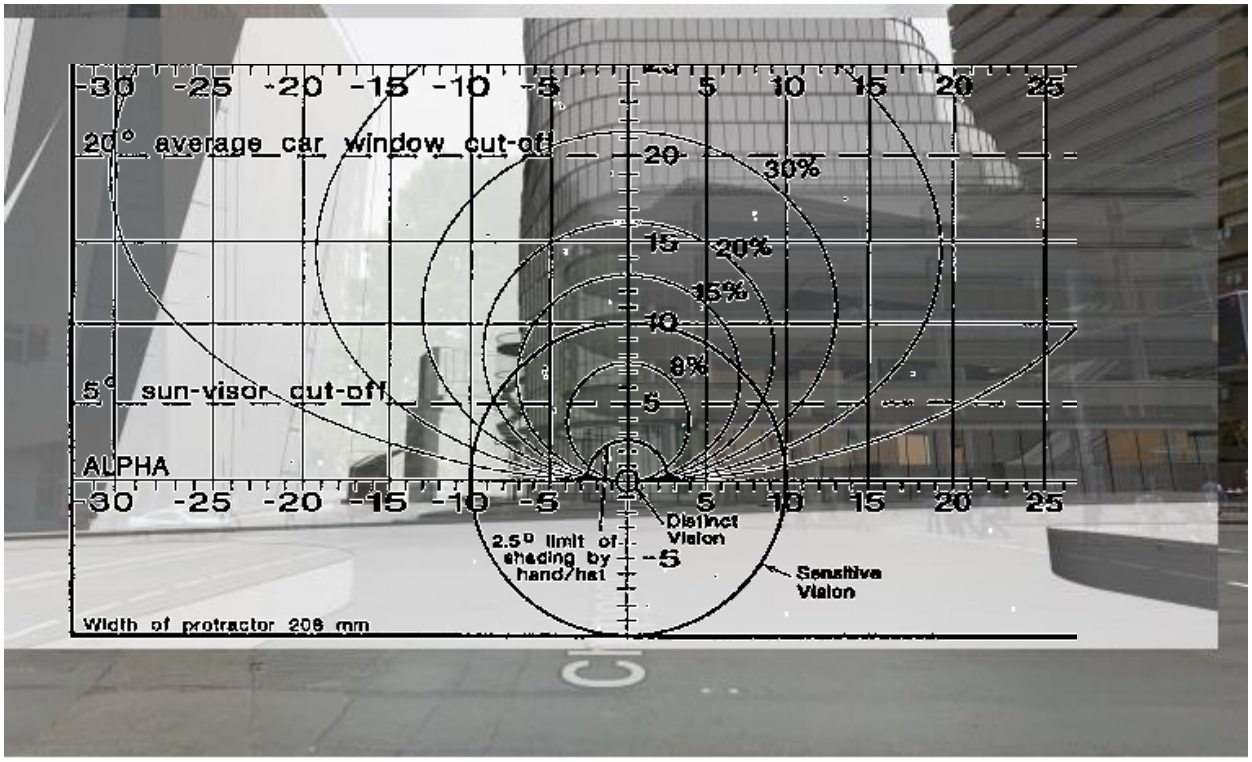


Figure 18 – 175° and 245° Façade Aspect Reflected Virtual Sun from Viewpoint 3

There is a reflected image of the sun that reaches Viewpoint 3 from Façade Aspect 245°. For a motorist exiting Chippendale Way onto Broadway there is the potential for the sun to cause disability glare to the driver. As all of the facade falls above the 5° sun visor cut off in cars, no further action is required. Please refer to viewpoint 8 for pedestrian viewpoint.

Viewpoint 4

Viewpoint 4 has been taken at a distance of 30m from the South-West apex of the building. It is taken from the viewpoint of a driver travelling East along Broadway. The view of the facade is partially obscured by the UTS Engineering and IT Building.

On Figure 19 below black and pink lines have been drawn to represent the bearing angles to the two extreme façade aspects of the building. The red arrow indicates the direction of travel and viewing.

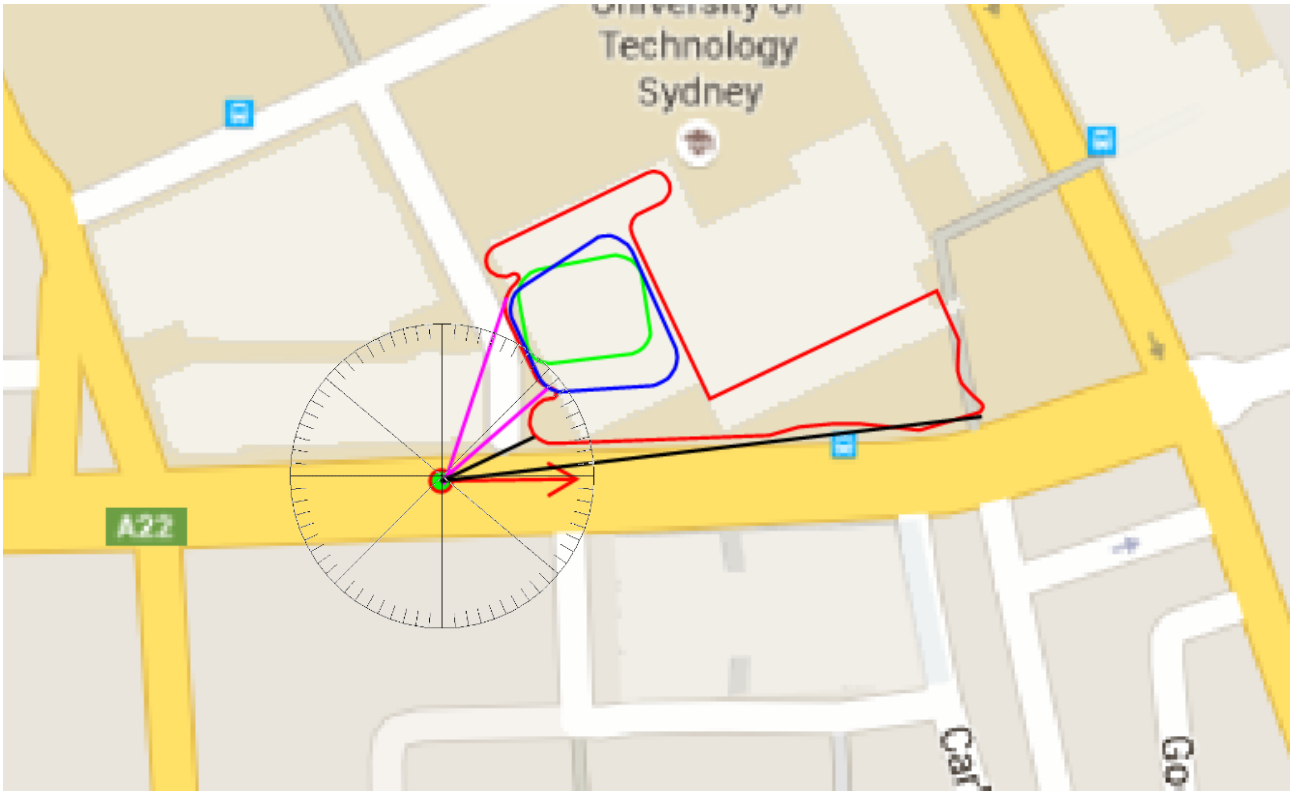


Figure 19 – Viewpoint 4 Horizontal Façade Aspect 245°, 265° and 175°

The vertical bearing angles have been calculated for the building

B_{podium} = $\tan^{-1}(32m \div 50.57m)$

= 32.69°

B_{tower} = $\tan^{-1}(73m \div 50m)$

= 55.59°

Viewing Direction		Vertical Bearing Angle		Horizontal Bearing Angle (0° at North)					
				Façade Aspect 245°		Façade Aspect 265°		Façade Aspect 175°	
		Lower Bound	Upper Bound	Left Bound	Right Bound	Left Bound	Right Bound	Left Bound	Right Bound
Podium	90°	0°	32.96°	20°	45°	NA	NA	80°	85°
Tower	90°	32.69	55.59	NA	NA	20°	45°	NA	NA

These bearing angles have been plotted on the reflected sun path diagrams in Figure 20,21,22 and 23 below.

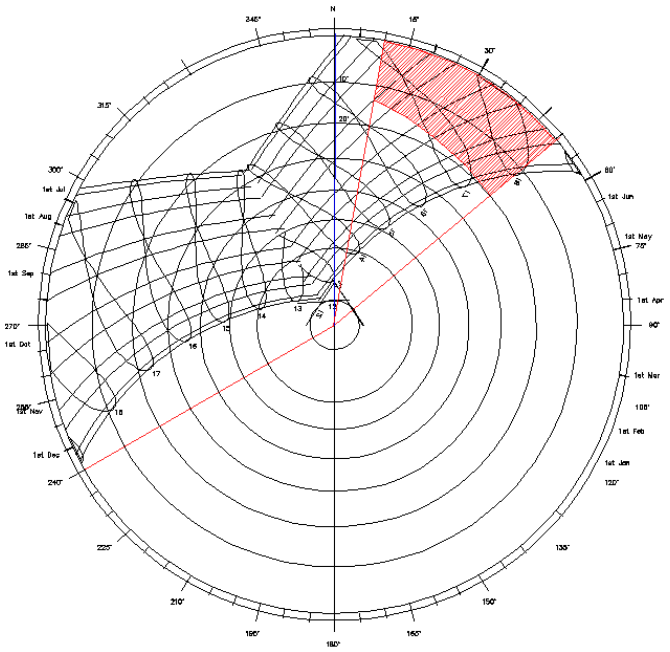


Figure 20 – 245° Façade Aspect Reflected Virtual Sun from Viewpoint 4

There is a reflected image of the sun that reaches viewpoint 4 from façade Aspect 245 17:00 till 19:00 between September and December°. In order to assess the façade a photo has been taken and overlayed with a rendering of the UTS façade (FJMT), a protractor is then applied at scale.

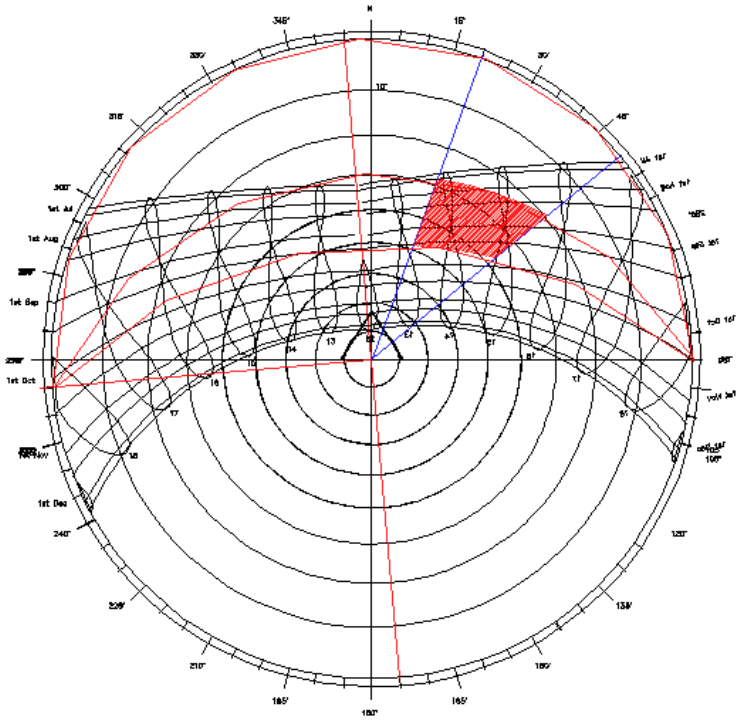


Figure 21 - 265° Façade Aspect Reflected Virtual Sun from Viewpoint 4

There is a reflected image of the sun that reaches viewpoint 4 from façade Aspect 265° at 13:00 till 15:00 between July and September. In order to assess the façade a photo has been taken and overlayed with a rendering of the UTS façade (FJMT), a protractor is then applied at scale.

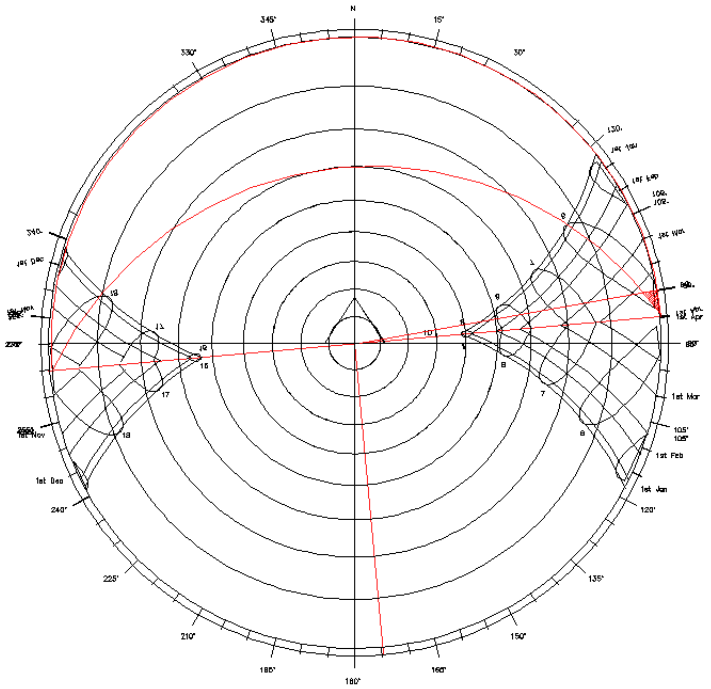


Figure 22 - 175° Façade Aspect Reflected Virtual Sun from Viewpoint 4

There is a reflected image of the sun that reaches viewpoint 4 from façade Aspect 175° at 06:00 in early April. In order to assess the façade a photo has been taken and overlayed with a rendering of the UTS façade (FJMT), a protractor is then applied at scale.

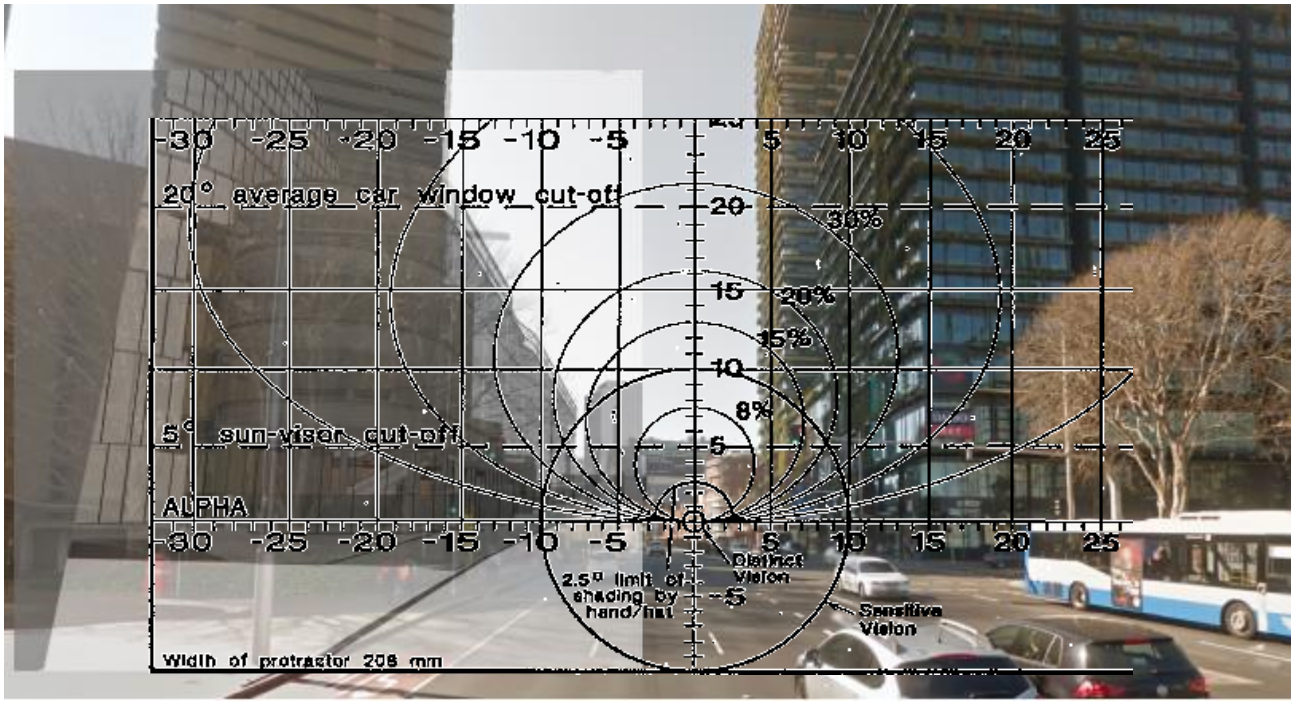


Figure 23 – Façade Aspect 245° Reflected Virtual Sun from Viewpoint 4

The proposed development, viewed from the direction of travel, is outside 20% reflectivity required by the City of Sydney and therefore no additional measures to reduce glare are required.

Viewpoint 5

View Point 5 is taken from the viewpoint of a motorist travelling east along Broadway.
On figure 24 below black obscured by the UTS Engineering and IT building. No further action required.

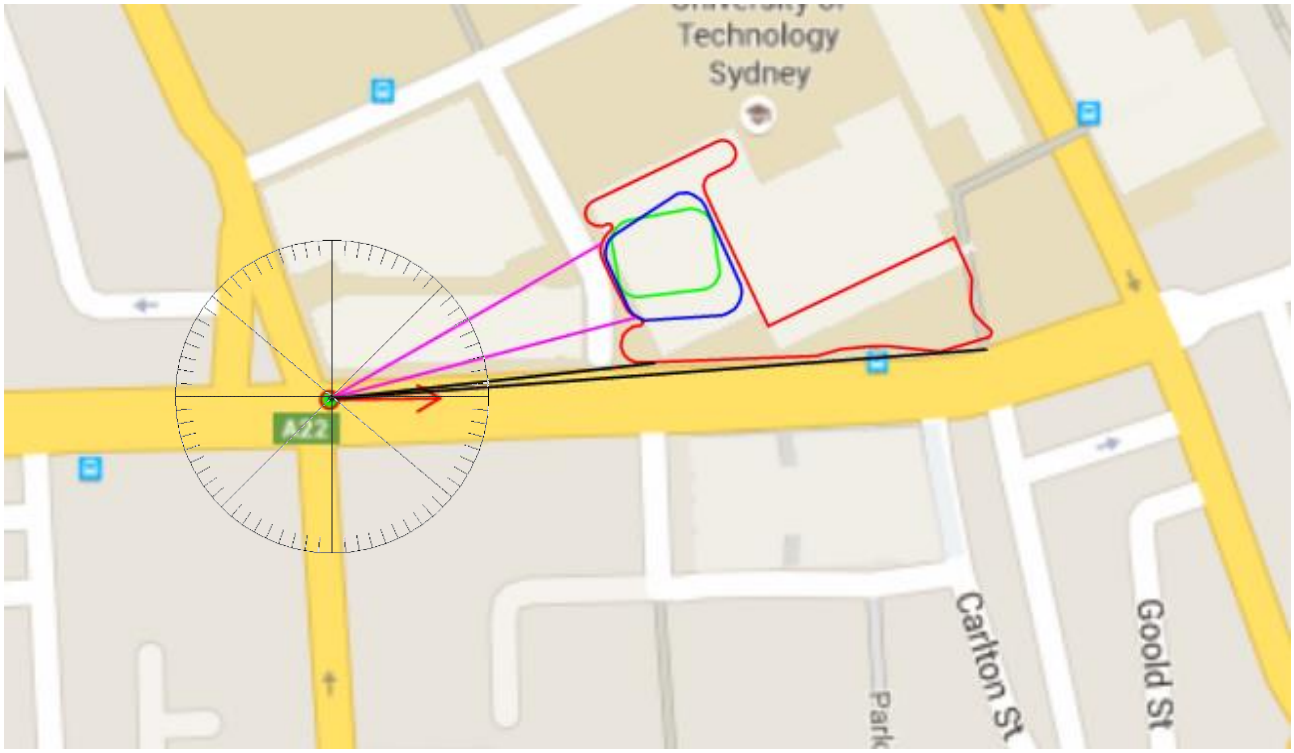


Figure 24 – Viewpoint 5 bearing angles

Figure 25 – 245° Façade Aspect Reflected Virtual Sun from Viewpoint 2

Viewpoint 6

Viewpoint 6 has been taken at a distance of 81m from the north-east apex of the building. It is taken from the viewpoint of a vehicle travelling south down Jones Street.

On Figure 26 below the black, blue and pink lines have been drawn to represent the bearing angles of the two extreme façade aspects visible to a pedestrian. The red arrow indicates the direction of travel and viewing.

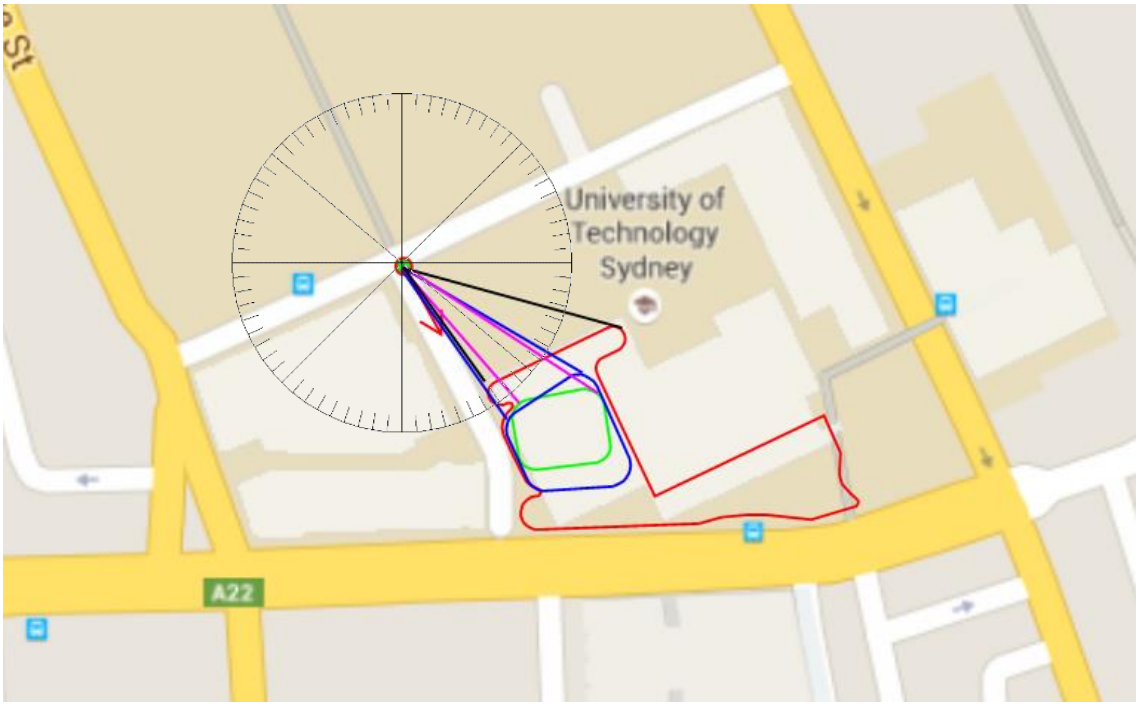


Figure 26 – Viewpoint 6 horizontal bearing angles

The vertical bearing angles have been calculated for the building.

B_{Podium} = $\tan^{-1}(32m \div 53m)$
= 31.19°

B_{tower2} = $\tan^{-1}(57m \div 81m)$
= 35.58°

B_{tower2} = $\tan^{-1}(73m \div 81m)$
= 41.58°

The façade aspect for the podium and lower tower portion are of the same orientation and have been grouped together in the table below

Viewing Direction		Vertical Bearing Angle		Horizontal Bearing Angle (0° at North)					
				Façade Aspect 333°		Façade Aspect 326°		Façade Aspect 355°	
		Lower Bound	Upper Bound	Left Bound	Right Bound	Left Bound	Right Bound	Left Bound	Right Bound
Podium	155°	0°	31.19°	155°	90°	N/A	N/A	N/A	N/A
Tower1	155°	31.19°	35.58°	N/A	N/A	155°	120°	N/A	N/A
Tower	155	35.58°	35.58°	N/A	N/A	N/A	N/A	150°	130°

These bearing angles have been plotted on the reflected sun path diagrams in Figure 277, 28, 29 and 30 below.

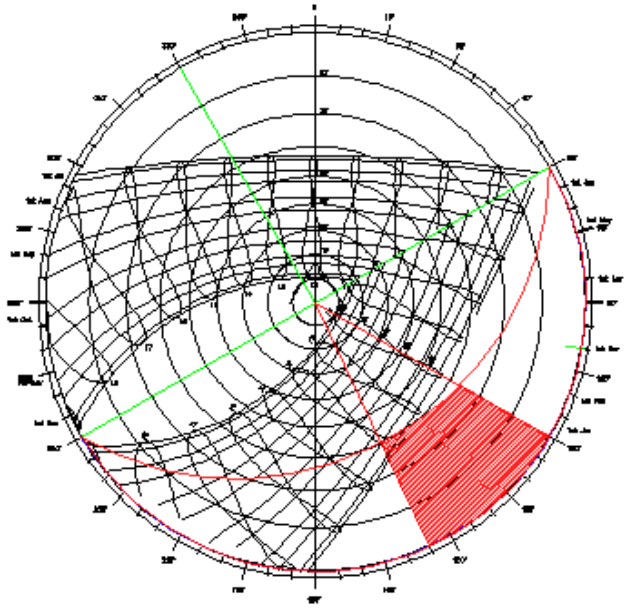


Figure 27 – 333° Façade Aspect Reflected Virtual Sun from Viewpoint 6

There is a reflected image of the sun that reaches viewpoint 6 from façade Aspect 333° at 14:00 in July. In order to assess the façade a photo has been taken and overlayed with a rendering of the UTS façade (FJMT), a protractor is then applied at scale.

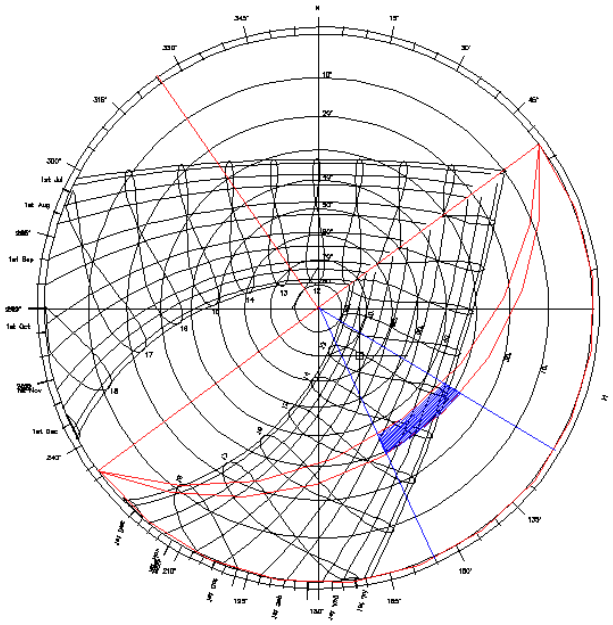


Figure 28- 326° Façade Aspect Reflected Virtual Sun from Viewpoint 6

There is a reflected image of the sun that reaches viewpoint 6 from façade Aspect 326 at 13:00 till 15:00 between July and August. In order to assess the façade a photo has been taken and overlayed with a rendering of the UTS façade (FJMT), a protractor is then applied at scale.

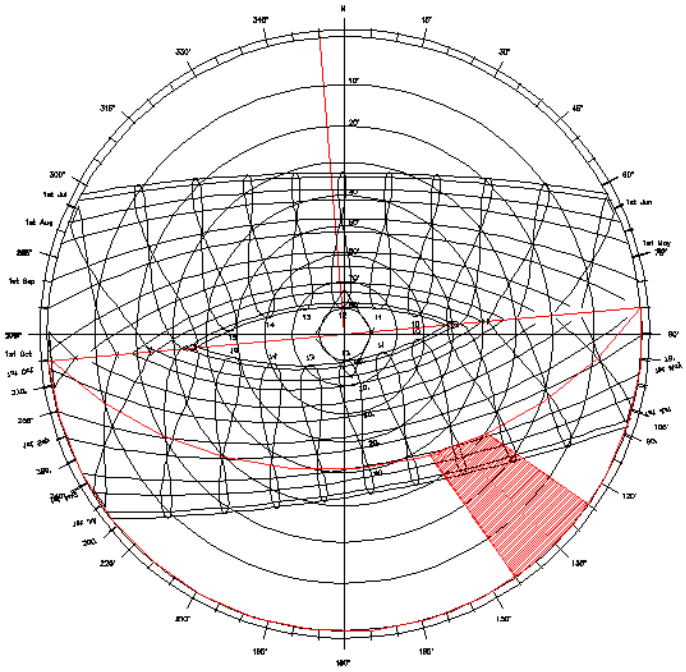


Figure 29 355° Façade Aspect Reflected Virtual Sun from Viewpoint 6

There is a reflected image of the sun that reaches viewpoint 6 from façade Aspect 355° at 09:00 till 10:00 between June and May. In order to assess the façade a photo has been taken and overlayed with a rendering of the UTS façade (FJMT), a protractor is then applied at scale.

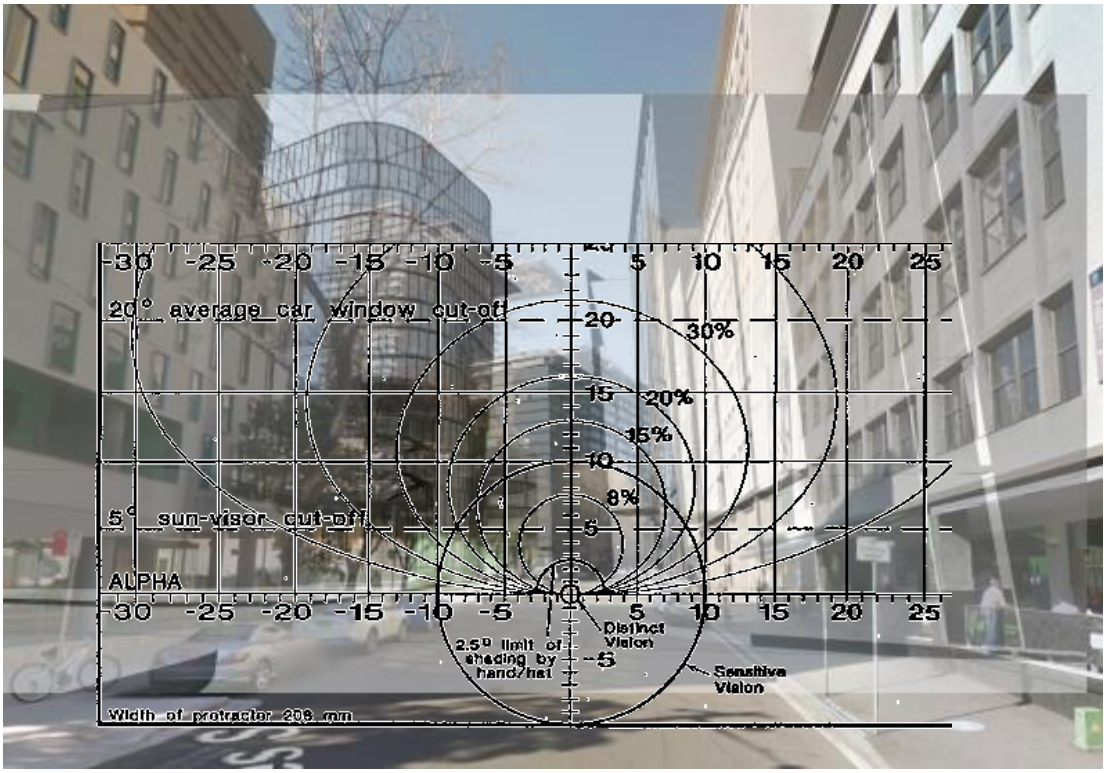


Figure 30 - 155° Façade as view from a pedestrian crossing the road

For a Driver travelling south along Jones Street at 13:00 till 15:00 between July and August there is a reflected image of the façade aspect 326° will reach the pedestrian. The reflected image of the sun is outside the 15% iso loops. Reflectivity the North Podium is to be limited to a reflectivity of less than 15%.

Viewpoint 7

Viewpoint 7 has been taken at a distance of 81m from the South-East apex of the building. It is taken from the viewpoint of a pedestrian crossing the road along Regent Street. The higher portion of the tower is obscured from the view of the pedestrian by the existing UTS tower.

On Figure 31 below black, blue and pink lines have been drawn to represent the bearing angles to the two extreme façade aspects of the podium and tower respectively. The red arrow indicates the direction of travel and viewing.

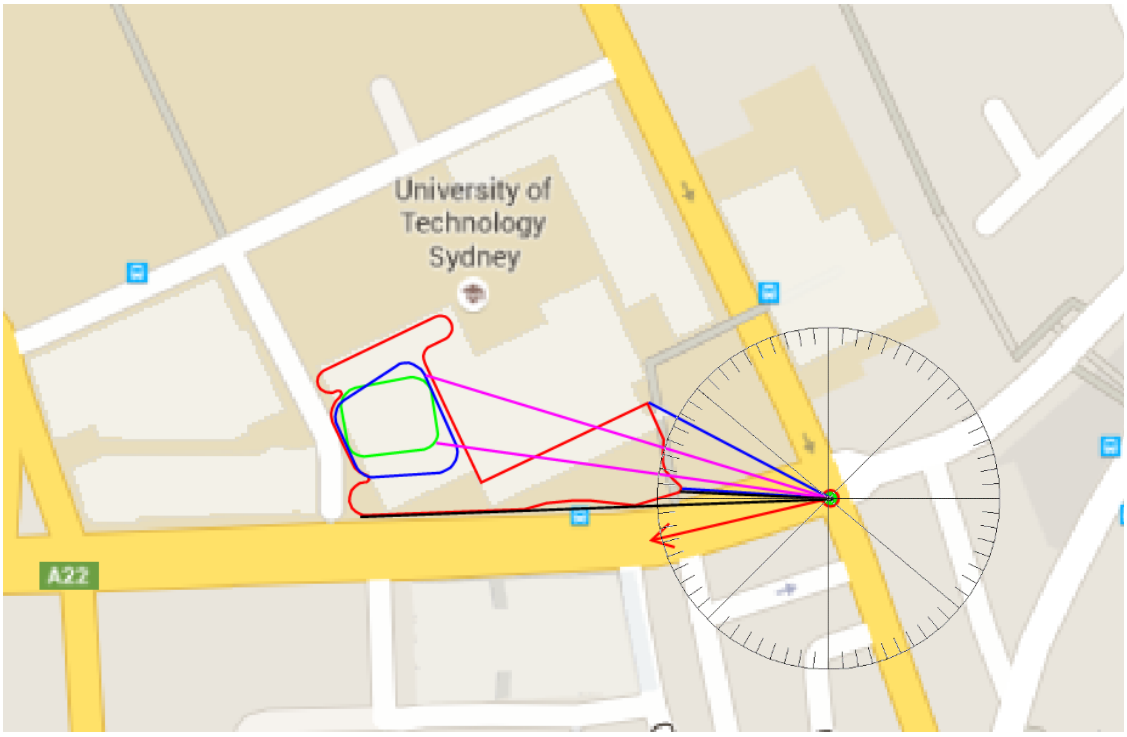


Figure 31 – Viewpoint 7 Broadway (Façade Aspect 65°)[6]

The vertical bearing angles have been calculated for the building

B_{podium} = $\tan^{-1}(30m \div 65m)$
= 24.5°

B_{tower1} = $\tan^{-1}(57m \div 150m)$
= 20.8°

B_{tower2} = $\tan^{-1}(73m \div 150m)$
= 25.9°

Viewing Direction		Vertical Bearing Angle		Horizontal Bearing Angle (0° at North)					
				Façade Aspect 65°		Façade Aspect 85°		Façade Aspect 175°	
		Lower Bound	Upper Bound	Left Bound	Right Bound	Right Bound	Left Bound	Right Bound	Left Bound
Podium	255°	0°	24.5°	270°	300°	NA	NA	265°	270°
Tower 2	255°	24.5°	25.9°	NA	NA	280°	290°	N/A	N/A

These bearing angles have been plotted on the reflected sun path diagrams in 32, 33 and 34.

[6] Google Maps

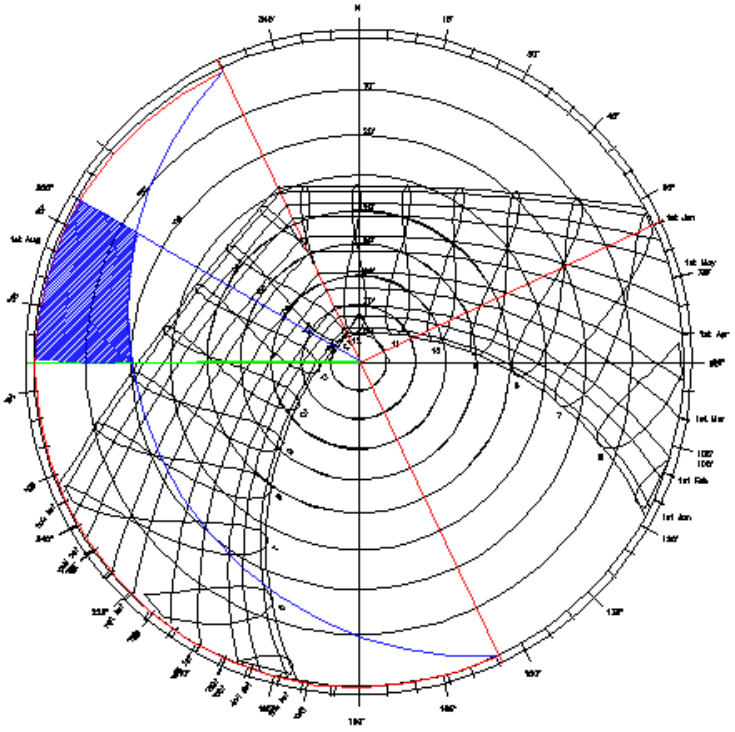


Figure 32 – 65° Façade Aspect Reflected Virtual Sun from Viewpoint 7

There is no reflected image of the sun that reaches Viewpoint 7 from Façade Aspect 65° of the building.

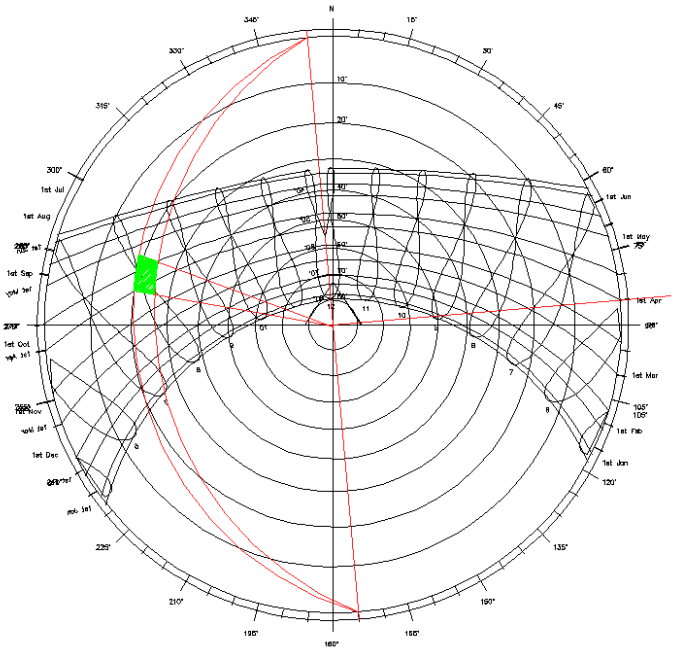


Figure 33 – 85° Façade Aspect Reflected Virtual Sun from Viewpoint 7

There is a reflected image that reaches Viewpoint 7 from Façade Aspect 85° of the building between 7:30am – 8:30am from late April to May. Between In order to assess the façade a photo has been taken and the glare protractor has been applied at scale has been aligned with the top of the building.

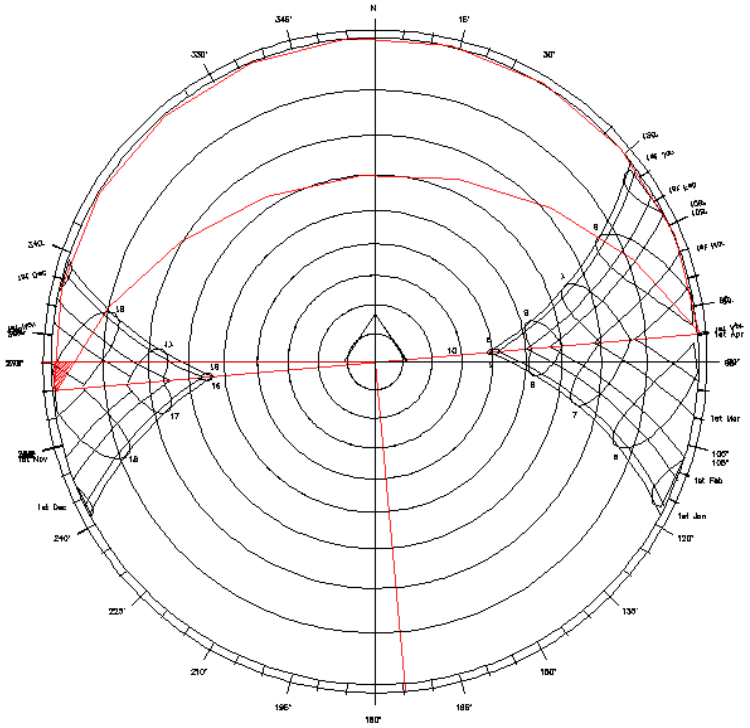
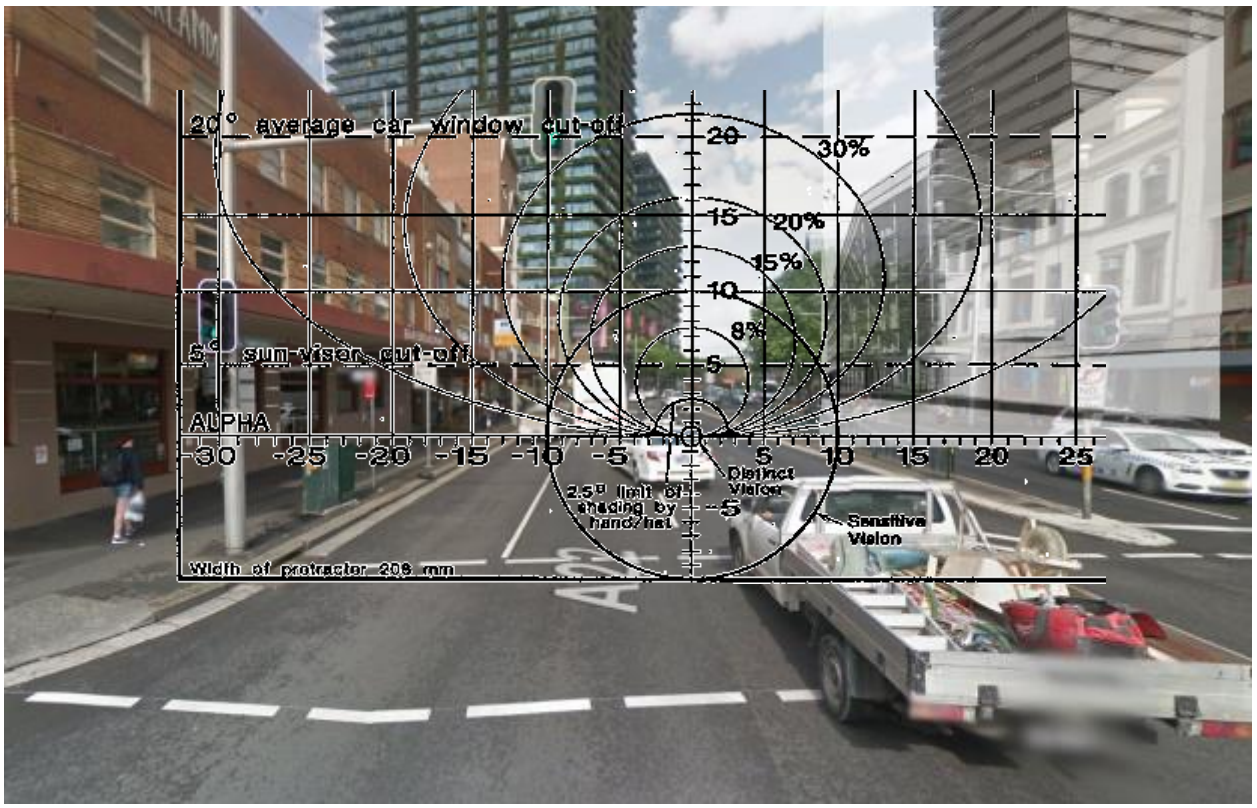


Figure 34 - 175° Façade Aspect Reflected Virtual Sun from Viewpoint 7

There is a reflected image that reaches Viewpoint 7 from Façade Aspect 175° of the building between 18:00 – 19:00 from late October to early November. In order to assess the façade a photo has been taken and the glare protractor has been applied at scale has been aligned with the top of the building.



The proposed development, viewed from the direction of travel, is outside 20% reflectivity required by the City of Sydney and therefore no additional measures to reduce glare are required.

Viewpoint 8

Viewpoint 8 has been taken at a distance of 30m from the South façade. It is taken from the viewpoint of a driver travelling North from the Chippendale way onto Broadway. The higher portion of the tower is deemed not to effect a vehicle as it is above the angle in the glare protractor.

On Figure 35 below the black and pink lines have been drawn to represent the bearing angles to extreme aspects of the facade. The red arrow indicates the direction of travel and viewing.

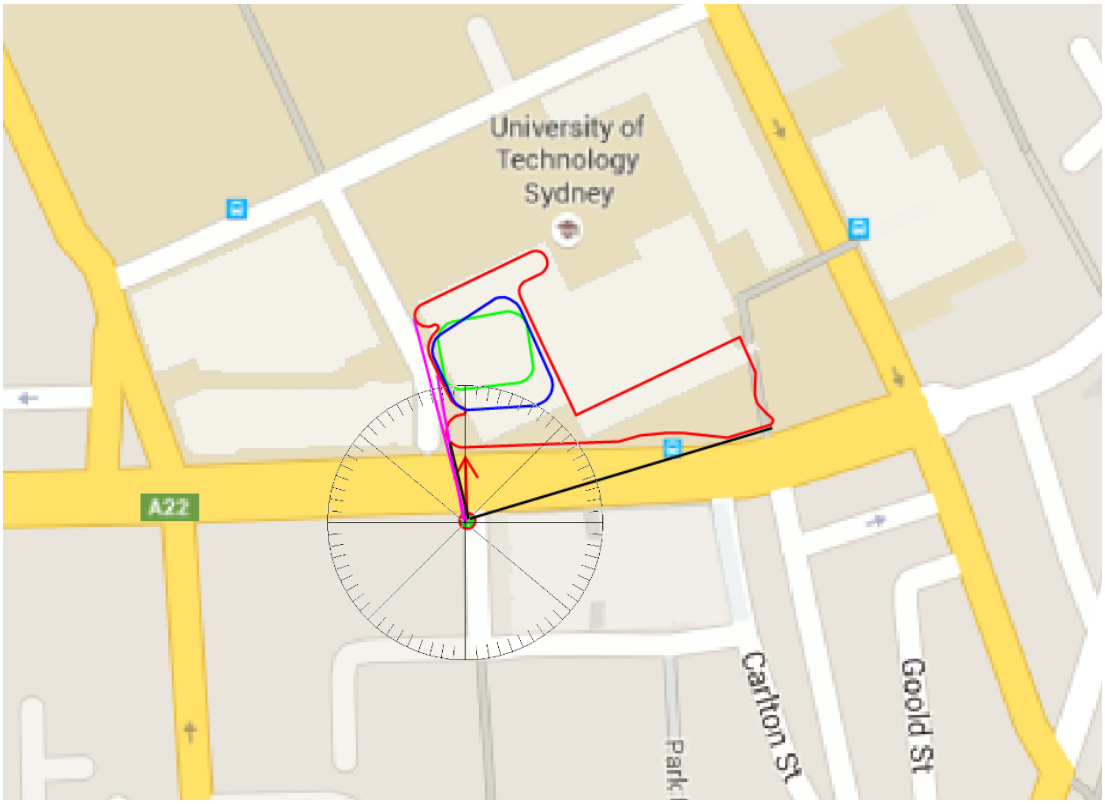


Figure 35 – Viewpoint 8 – Façade Aspect 175/245° horizontal bearing angles[7]

The vertical bearing angles have been calculated for the Building

B_{podium} = $\tan^{-1}(32m \div 35.9m)$
= 39.11°

$B_{podium2}$ = $\tan^{-1}(50m \div 75m)$
= 21.11°

B_{Tower} = $\tan^{-1}(73m \div 55m)$
= 47.1°

Viewing Direction		Vertical Bearing Angle		Horizontal Bearing Angle (0° at North)			
				Façade Aspect 175°		Façade Aspect 245°	
		Lower Bound	Upper Bound	Left Bound	Right Bound	Left Bound	Right Bound
Podium	355°	0°	39.11°	350°	70°	345°	350°

These bearing angles have been plotted on the reflected sun path diagrams and below.

[7] Google Maps

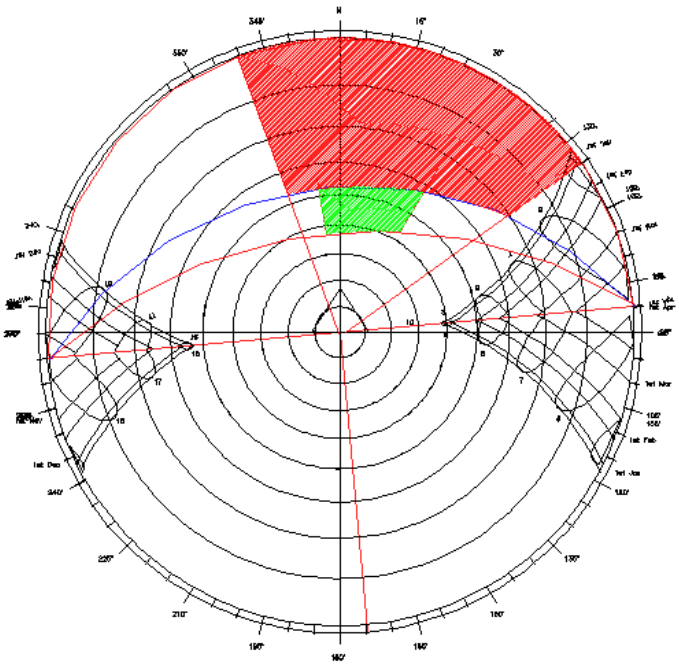


Figure 36 – 175° Façade Aspect Reflected Virtual Sun from Viewpoint 8

There is a reflected image of the sun that reaches viewpoint 8 from façade Aspect 175° at 5:30am in early January. In order to assess the façade a photo has been taken and overlayed with a rendering of the UTS façade (FJMT), a protractor is then applied at scale.

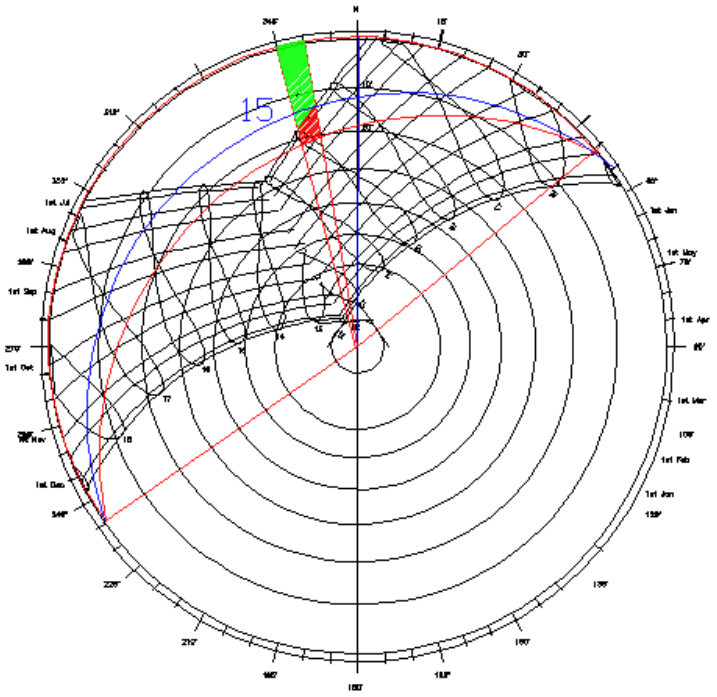


Figure 37- 245° Façade Aspect Reflected Virtual Sun from Viewpoint 8

There is a reflected image of the sun that reaches viewpoint 8 from façade Aspect 245° at approximately 3pm from July to August. The surface that the reflected image of the sun occurs between the 15° and 20°. In order to assess the façade a photo has been taken and overlayed with a rendering of the UTS façade (FJMT), a protractor is then applied at scale.

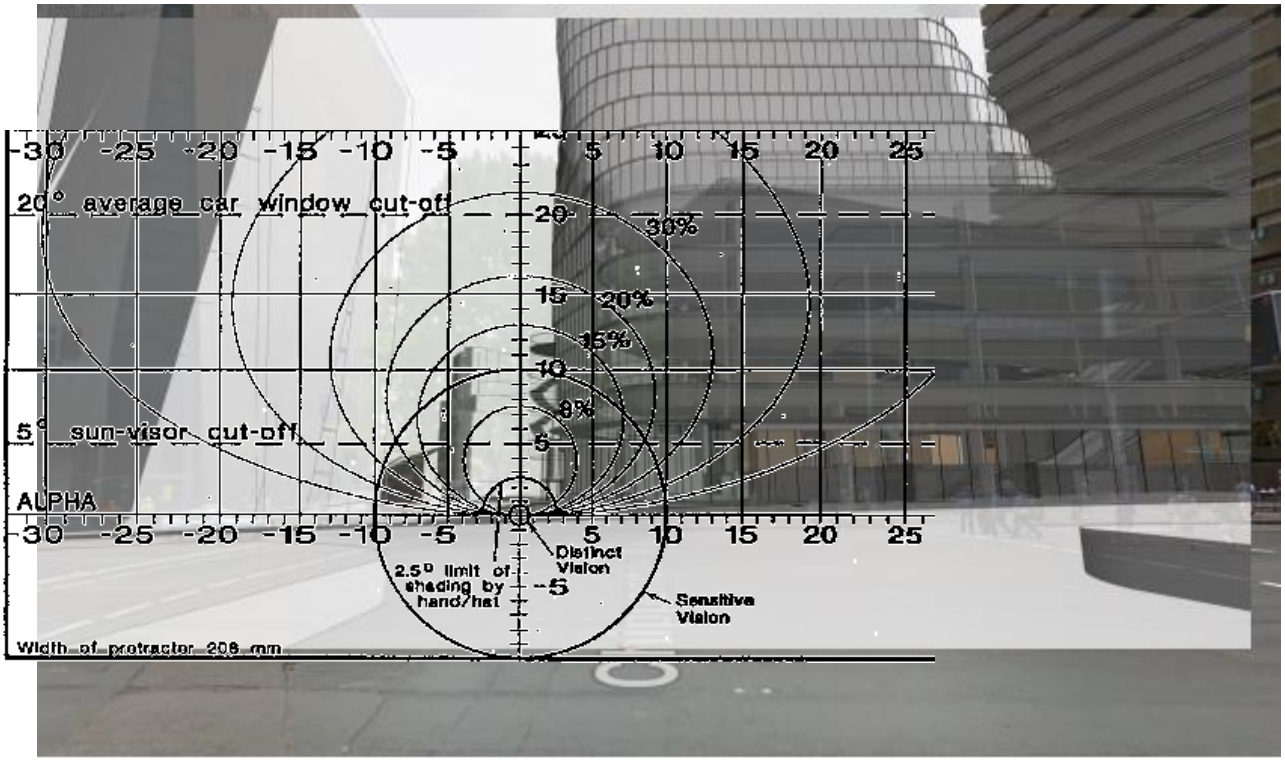


Figure 38 – 175°/245° Façade Aspect Reflected Virtual Sun from Viewpoint 8

The reflected image of the sun does not reach Viewpoint 8 from the façade aspect 175°. From figure 38 the reflected image from the tower is above the 20% iso loops, and the reflected image from podium is from the right (not in sight). No further action required

There is a reflected image of the sun that reaches Viewpoint 8 from Façade Aspect 245°. For a pedestrian crossing the road at 3:45pm-5:00pm in the months of July and August there is a reflected image of the façade aspect 245° will reach the pedestrian. The reflectivity occurs between the 15° and 20° bearing angle. The reflectivity of the façade is to be less than 15% from Ground to Level 7 on the western façade.