



Our Ref: J085821

7 August 2015

Development Project Manager
Barangaroo South
Lend Lease
30 The Bond, 30 Hickson Road
MILLERS POINT NSW 2000
Attention: Ms Cherylene Teoh

Dear Ms Teoh

Re: Sydney Observatory Sky View Loss Assessment - Barangaroo South Towers R4a (SSD 6964) and R4b (SSD 6965)

1. BACKGROUND

I refer to my report of 23rd September, 2014 on this subject. The report was based on the Concept Plan for the site. That plan specified a height of 250.0 and 210.0 metres AHD respectively for towers R4a and R4b.

The following represents a summary of the report's findings:

1. Only residential towers R4a and R4b sit within the view corridor from Sydney Observatory.

2. The four sky targets flagged by Sydney Observatory are generally not observable for a period of about one month, centred on September each year, due to the view obstruction caused by the tops of the two buildings.
3. Some sky targets are obscured for only parts of some nights during this period. These nights should not be considered problematic because if the target viewing schedule is arranged appropriately by the observatory, the affected targets could be viewed first, while they are still unobstructed, with no real inconvenience to the observatory.
4. Based on Bureau of Meteorology weather data for Observatory Hill for September, on average:
 - There will be some cloud cover for about half of the time
 - There will be 10.9 clear days
 - There will be 8.5 days when it is totally clouded over.
5. The seeing conditions for the part of the sky immediately above the two buildings will generally be poor due to its low elevation, the large air mass through which it is viewed, the light pollution from nearby bright sources such as the Harbour Bridge, the effects of smog, scintillation, humidity and so forth.
6. Consequently, viewing targets around the area obstructed by the buildings would be done under observing conditions that are far from ideal, and the image quality is expected to be relatively poor on most nights.

2. REVISED ASSESSMENT OF SKY VIEW OBSTRUCTION BASED ON APPROVED PLANS FOR TOWERS R4A AND R4B

Approval has now been granted by the Department of Infrastructure and Regional Development for the Commercial and Hotel towers.

I have reviewed the approved plans for towers R4a and R4b. These plans now specify proposed maximum building heights of 250.0 and 210.0 metres, these being the same as provided for the Concept Plan.

3. COMMENTS ON CONTRIBUTION TO SKY GLARE

I have addressed the issue of sky glare in Section 5.2 of my report.

In summary, the observing conditions at Sydney Observatory for low elevation targets in a South West direction are poor, even on clear nights.

Glare from nearby brightly lit objects (e.g. Harbour Bridge, other city buildings, street lighting etc.) will illuminate the background sky, thereby degrading the contrast of sky images. Viewing of bright targets such as individual stars and star clusters (e.g. the Pointers, the Southern Cross and the Jewel Box cluster) will be much less affected than viewing faint objects such as ω Centauri.

In addition, I have been advised that a number of measures have been implemented as part of the design of these two buildings to keep to a minimum the amount of lighting, and in particular the amount of light directed upward. These measures include:

- Keeping brightly lit surfaces to a minimum
- Fitting luminaires with light shields
- Keeping the colour temperature of light sources low
- Minimising the amount of upward directed lighting

In my view, the abovementioned measures should ensure that the additional sky glare introduced by the two buildings would not significantly degrade observing the night sky from Sydney Observatory in all directions other than those immediately above the two buildings.

Yours faithfully,



George Georgevits (B.E. Hons)
Consulting Engineer



COMMERCIAL-IN-CONFIDENCE

Report prepared on behalf of Expert Opinion Services
A business of UNSW Global Pty Limited

BARANGAROO SOUTH PROJECT

Sydney Observatory Sky View Loss

Assessment - Detailed Response to the Issues

Raised in Sydney Observatory's Submission to

NSW Planning and Environment

for

Lend Lease Group

Your reference:

by

Mr George Georgevits (B.E. Hons)

Consulting Engineer

Date of Issue: 11 August 2015

Our Reference: J085821

CONTENTS

	Page
1. TERMS OF REFERENCE	1
1.1 QUALIFICATIONS	1
1.2 TERMS OF ENGAGEMENT	2
2. SITE VISIT AND GENERAL COMMENTS ON OBSERVING CONDITIONS AT OBSERVATORY HILL	3
3. THE MAAS SUBMISSION COVERING LETTER	12
SUMMARY IMPACT	12
4. THE MAAS SUBMISSION REPORT	14
4.1 IMPACT OF THE CONCEPT PLAN ON SYDNEY OBSERVATORY OPERATIONS.....	14
4.2 RESPONSE TO THE UNSW GLOBAL IMPACT ASSESSMENT	19
4.3 DETAILED RESPONSE	25
 APPENDIX 1: Sydney Observatory Public Viewing Schedule	
APPENDIX 2: Science Article	
APPENDIX 3: Curriculum Vitae	
APPENDIX 4: Capability Statement for PDI	

1. TERMS OF REFERENCE

1.1 QUALIFICATIONS

- 1 This report was prepared by George Georgevits, managing director and principal consulting engineer for Power and Digital Instruments Pty Ltd (PDI).
- 2 I have an honours degree in electrical engineering and 40 years experience as an engineer, specialising in the fields of communications, electronics and power.
- 3 In addition, I am presently undertaking a PhD in Astrophysics at the University of New South Wales.
- 4 My PhD work has entailed the use of the 1.3 metre UK Schmidt Telescope and the 0.5 metre Automated Patrol Telescope, both located at Siding Spring Observatory, Coonabarabran NSW.
- 5 I have conducted presentations of my work at a number of overseas and Australian conferences on Astrophysics.
- 6 An article referencing my work has appeared in Science magazine (see Appendix 2), and it has been cited in a paper appearing in Nature.
- 7 I have co-authored a Chapter in a textbook on the outer solar system.
- 8 I have owned and operated a number of small astronomical telescopes over the years.
- 9 I am thus very familiar with observational astronomy and also the astronomical objects that are the subject of this matter.
- 10 A brief CV for George Georgevits is provided in Appendix 3 and a brief capability statement for PDI is provided in Appendix 4.

1.2 TERMS OF ENGAGEMENT

- 11 I have been engaged by Lend Lease to provide astronomical advice in relation to this matter.
- 12 I have prepared two reports dated 23 September 2014 (the first report) and 21 May 2015 (the second report) addressing the loss of sky view from Sydney Observatory North Dome due to the construction of residential Towers R4a (SSD 6964), R4b (SSD 6965) and the Crown Hotel.
- 13 The first report specifically addressed the viewing concerns raised by Sydney Observatory at a meeting with Lend Lease in December 2013, in terms of specified sky targets and viewing corridors.
- 14 The second report addresses additional viewing concerns raised by Sydney Observatory in recent correspondence wherein the azimuth of their required viewing corridor has been increased so that it now includes additional sky target(s) potentially obscured by the Crown Hotel building (**the Hotel**).
- 15 On 7 May 2015, the Museum of Applied Arts and Sciences (**MAAS**) made a submission (**the MAAS submission**) to NSW Department of Planning and Environment (**the Department**) in the form of a formal response to the development application submitted to the Department by Lend Lease for the Barangaroo South Mod 8 Concept Plan (MP06_0162MOD8).
- 16 The MAAS submission consisted of a covering letter that addresses the following:
- the relevant background information concerning the history and significance of the Observatory,
 - a summary of their position concerning the impact that the Barangaroo project will have on sky view from Sydney Observatory and on their observing operations ,
 - a detailed report that has been prepared as a response to my first report.

- 17 I have been instructed to provide a detailed response to the issues raised in the MAAS submission.

2. SITE VISIT AND GENERAL COMMENTS ON OBSERVING CONDITIONS AT OBSERVATORY HILL

- 18 I personally visited the observatory during daytime on 19 May 2015 in order to get a first hand appreciation of the issues raised in the MAAS submission and earlier correspondence from the observatory, and to see if there were any other relevant factors that had not previously been explored.



Fig 2.1 – View of the site looking North

- 19 I did not attend a night time observing session.
- 20 I was advised by the observatory receptionist that their observing sessions run for approximately 90 minutes, typically have 20 attendees and that it was necessary to book ahead because the sessions were well attended and heavily booked.
- 21 I was further advised that due to the number of attendees and the limited duration of each session, typically no more than 5 sky targets are viewed during any one observing session.

- 22 The observatory has a number of telescopes at its disposal for observing, ranging in size from the 16" Meade mounted in the North Dome down to 8" and smaller, portable instruments suitable for setting up in the courtyard.



Fig 2.2 – View of South and North Domes, and courtyard, looking North

- 23 The view from the courtyard is much more restricted at low altitudes than that from the North Dome, due to its lower elevation and the presence of trees (see Fig 2.2).
- 24 Thus the issues raised in the MAAS submission are applicable primarily to the sky view as seen from the North Dome.
- 25 From my inspection of the site and environs, I also noted that there were a number of tall city buildings much closer to the site than the Barangaroo development (see Figs 2.3 to 2.8 below).



Fig 2.3 – Other close-by tall buildings, with the Barangaroo site and associated crane visible immediately to the right of the cream coloured residential tower. The grey tower on the left also appears to be residential.



Fig 2.4 – High rise buildings in the background looking approximately South from the observatory courtyard. The grey tower in Fig 2.3 is also just visible on the far right.



Fig 2.5 – Closeup photo of the Highgate building taken from just outside the observatory North Dome, with the Barangaroo development immediately behind on the right.

- 26 There are a number of other high-rise commercial buildings in close proximity to the observatory that would present bright light sources at night.

- 27 These would contribute to the unwanted light pollution and background sky brightness.



Fig 2.6 – Looking South from near the North Dome



Fig 2.7 – Other high-rise light sources looking South East from the courtyard)



Fig 2.8 – Other high-rise light sources looking South East from outside the observatory grounds

- 28 These high-rise buildings are all older than the Barangaroo development and presumably have no measures in place to control night time light output.
- 29 In addition, there is the Sydney Harbour Bridge and other brightly lit nearby Sydney icons, such as the Opera House and the Sydney passenger terminal, all very bright night time light sources.



Fig 2.9 – Sydney Harbour Bridge viewed from Observatory Hill

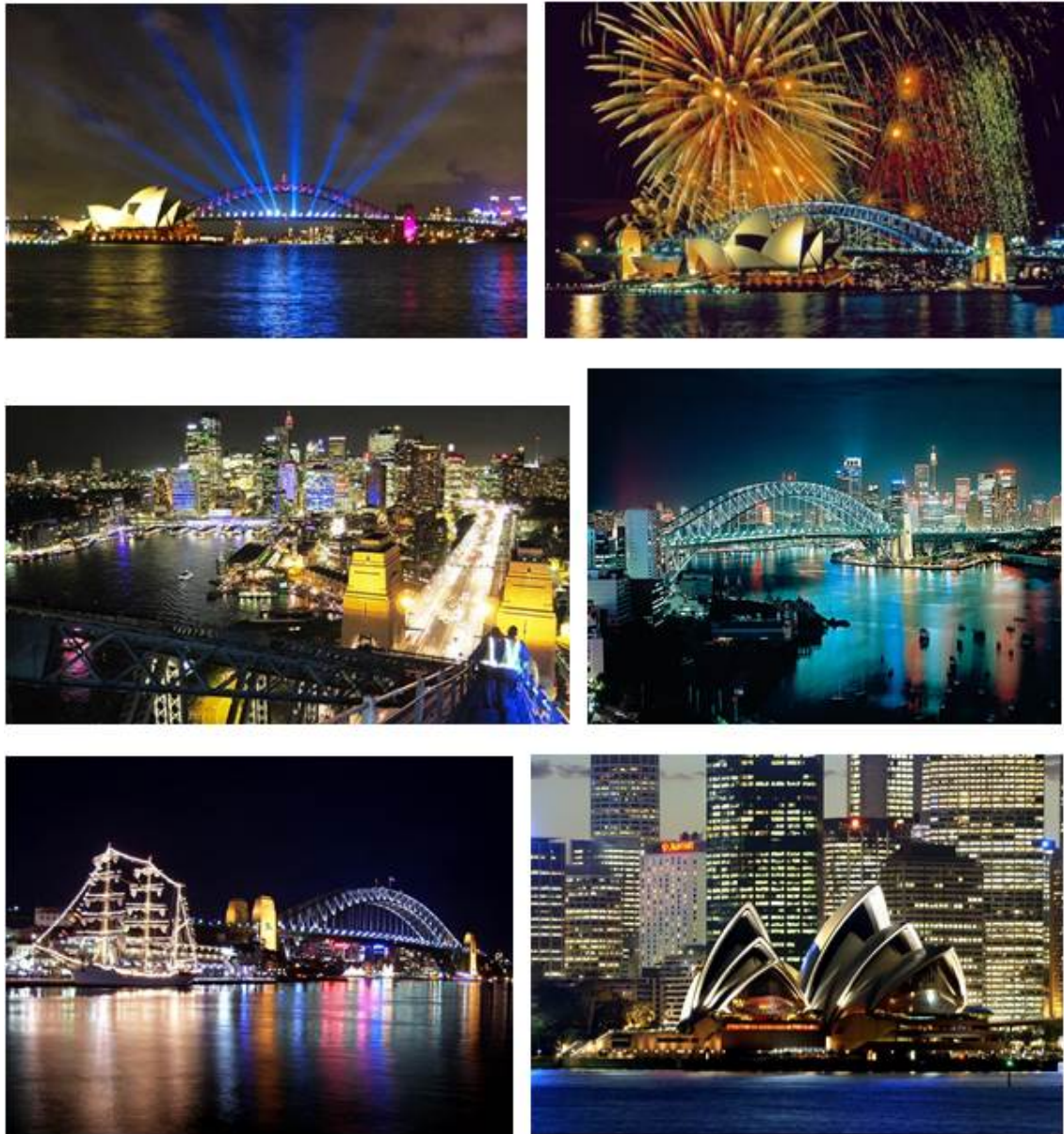


Fig 2.10 – Sydney Harbour Bridge and other nearby brightly lit Sydney icons.

The centre right photo, taken from the lower North Shore, west of the Bridge, clearly shows the sky glow above the Sydney CBD due to the large number of bright light sources.

- 30 In addition, special events on and around Sydney Harbour often involve very bright lighting and also particulate pollution when fireworks are involved.
- 31 The Earth's atmosphere scatters light, so that when viewing a sky object, the brightness of the background sky near the target object is a function of, amongst other things, the amount of upward directed light near the observer and the air mass through which the object is observed.

- 32 Thus the background sky is brighter at lower observation altitudes because of the greater air mass in the viewing path.
- 33 There are so many existing bright light sources near the observatory that, in my opinion, observing conditions are poor, even on the best nights, due to the brightness of the background sky.
- 34 The additional light emanating from the Barangaroo development buildings, when completed, may further degrade the situation, though in my opinion the impact on observing will be marginal to no impact at all.
- 35 As upward directed light control measures will be incorporated in the design of these buildings, the impact on observing is expected to be much less than that of the other, closer existing buildings, where light control measures are unlikely to have been implemented.
- 36 I have no way of confirming whether light control measures have been implemented in the other nearby buildings. However, the residential apartments will be fitted with a variety of internal lighting arrangements, depending in the personal choices of the occupants, and will contain other bright light sources (e.g. large plasma screens). These cannot be controlled and may emit significant light in the direction of the observatory during observing sessions.
- 37 For the reason given in 32 above, the adverse effect of these bright light sources can be minimised by observing sky objects at high altitudes.

3. THE MAAS SUBMISSION COVERING LETTER

SUMMARY IMPACT

- 38 Sydney Observatory is only open for observing at specific times on specific nights of the year (refer Appendix 1).
- 39 The site currently operates as an astronomical museum with a public outreach program.
- 40 Its long tradition of significant astronomical activity is noted, but is not considered relevant to the issue at hand - I was advised by the receptionist that scientific observing from the site ceased sometime in the 1980's.
- 41 The report prepared by UNSW Global does not describe the additional impacts generated by Mod 8 on the Observatory as "negligible".
- 42 I disagree that there are inaccuracies in the report I prepared through UNSW Global.
- 43 I agree that the Mod 8 concept plan buildings will have some effect on the time during which the stated four objects are visible from the North Dome of the Observatory during August and September of each year.
- 44 I also note that the Celestron telescope that is mounted in the North Dome and used by the observatory for these observing sessions cannot be used to view the Southern Cross in its entirety, because the field of view of this telescope is too small to fit the whole of the Southern Cross.
- 45 Rather than address the percentages of lost viewing opportunity as presented in the MAAS Submission covering letter, I have addressed all of the issues in detail by providing a point by point response to the Sydney Observatory review report.

- 46 As to whether the obstruction caused by the Mod 8 design will impact the Observatory's capacity to generate visitation and related revenue, in my opinion, this is unlikely because:
- During August and September of each year (the only months where the specified sky targets are affected), there are plenty of other sky target objects that are far better placed in the sky for viewing than the four objects in question, and some of these could be selected for viewing,
 - Only five objects are viewed during each observing session,
 - The vast majority of visitors are not going to know beforehand which objects are suitably placed in the sky for viewing, and the four objects in question are not visible for part of the year anyway, because they are either too close to or set below the horizon,
 - Thus prospective visitors are unlikely to not visit the observatory on the basis that, for example, the Southern Cross is not visible on any particular night,
 - There are literally hundreds of other interesting objects in the sky suitable for viewing with a moderate size telescope, and the observatory could, and in order to provide the best possible viewing experience, should choose objects that are much better placed in the sky for viewing.
- 47 I note that the final paragraph of the covering letter states that the Observatory conducts three guided astronomy sessions each night.
- 48 This appears to conflict with the information contained in the attached report from Sydney Observatory and with their advertised observing schedule which states that during the period in question (August to September of each year), two observing sessions are conducted (refer Appendix 1).
- 49 In my first and second reports, I have prepared the lost viewing time analysis on the basis that the observatory conducts two observing sessions per night.

4. THE MAAS SUBMISSION REPORT

4.1 IMPACT OF THE CONCEPT PLAN ON SYDNEY OBSERVATORY OPERATIONS

50 In my responses below, I have provided the relevant excerpts from the
Sydney Observatory report that accompanied the MAAS submission, followed
by my comments.

Building H1 limits viewing of the globular cluster Omega Centauri.

51 I agree that Building H1 reduces the viewing opportunities for Omega Centauri
during the month of August and for the beginning of September each year.

52 However, this sky object is relatively faint (visual magnitude ~3.6), and
observing it at low altitude under bright sky conditions such as those found at
Sydney Observatory (with or without the Barangaroo development) would
produce very poor results.

53 In my view, during the month of August, when ω Centauri is low in the sky, a
far better approach would be to observe another similar globular cluster that is
at a much higher altitude at that time of year (e.g. 47 Tucanae – see Fig 4.1
below).



Fig 4.1 – Photos of 47 Tucanae (left) and ω Centauri (right)

Buildings R4A and R4B limit viewing of the constellation Southern Cross, the star Alpha Centauri (and its companion Pointer star Beta Centauri) and star cluster the Jewel Box.

54 As detailed in my first report, the viewing opportunities for these four sky targets are reduced by buildings R4A and R4B during the months of August and September each year.

55 However, similar comments apply to these objects, in so far as:

1. as they are best observed when they are at higher altitudes in the sky,
2. typically only five objects are viewed during each observing session,
3. there are literally hundreds of other interesting sky target objects to choose from.

Building H1 limits viewing of Omega Centauri during both the first and second evening viewing sessions. In the first session it causes a loss of viewing on 28 days, or 15% of the presently available viewing days. It causes a loss of viewing for 20 hours and 46 minutes, or 8% of the presently available viewing time. In the second viewing session it causes a loss of viewing on 41 days, or 21% of the presently available viewing days. It causes a loss of viewing for 27 hours and 23 minutes, or 11% of the presently available viewing time.

56 I have provided a table of progressive dates and times where the Crown Hotel obstruction causes loss of viewing opportunity for sky target ω Centauri from Sydney Observatory in Fig 6.6 of my second report.

57 I consider further comparisons such as the percentage of viewing days and hours lost somewhat meaningless and disingenuous because factors such as weather, bright of Moon, major Sydney events involving light shows etc. also have a major impact on viewing opportunities, and how viewing opportunities are defined also affects these statistics (see section 4.2, paragraph 84 below for details).

58 Most importantly, ω Centauri is a relatively faint sky object, and viewing it at low elevation under bright sky conditions will yield a very poor image.

- 59 I reiterate that ω Centauri is not a good choice of sky target under these conditions, and that other similar globular clusters that are at higher altitude at this time (such as 47 Tucanae) would provide a far better viewing experience.

Buildings R4A and R4B limit viewing of the star Alpha Centauri during the second viewing session only. They cause a loss of viewing on 57 days, or 25% of the presently available viewing days. They cause a loss of viewing for 45 hours and 11 minutes, or 15% of the presently available viewing time.

Buildings R4A and R4B limit viewing of the Southern Cross during both the first and second sessions. In the first session they cause a loss of viewing on 32 days, or 18% of the presently available viewing days.

They cause a loss of viewing for 24 hours and 38 minutes, or 9% of the presently available viewing time. In the second session they cause a loss of viewing on 41 days, or 21% of the presently available viewing days. They cause a loss of viewing for 27 hours and 7 minutes, or 10% of the presently available viewing time.

Buildings R4A and R4B limit viewing of the Jewel Box during both the first and second sessions. In the first session they cause a loss of viewing on 22 days, or 12% of the presently available viewing days. They cause a loss of viewing for 15 hours and 55 minutes, or 6% of the presently available viewing time. In the second session they cause a loss of viewing on 46 days, or 22% of the presently available viewing days. They cause a loss of viewing for 29 hours and 8 minutes, or 11% of the presently available viewing time.

- 60 In Fig 4. of my first report I have provided a table showing the times during which obstructions of these specific sky targets caused by buildings R4A and R4B takes place.

- 61 For the reasons given in paragraph 57 above, I do not consider further calculations of viewing loss times or percentages warranted or productive.

- 62 These selected target objects are at very low altitudes at this time and in my opinion, other sky targets at higher altitudes, where the background sky is darker, would provide a far better viewing experience (keeping in mind that each session is typically limited to only five sky objects).

The whole Barangaroo South precinct, but particularly buildings R4A, R4B and H1, will spill light to the sky reducing the contrast between the background sky and objects viewed from Sydney Observatory making objects more difficult to view.

63 I agree that these buildings will spill some light to the sky, but I reiterate that:

- The other closer high rise buildings where light control measures are unlikely to have been implemented will have a much greater adverse effect, and
- It is not good practice to observe sky objects (particularly faint objects) at low altitude under bright background sky conditions due to the adverse effects of observing through the larger air mass (higher background sky brightness and more air turbulence).

Conclusion

- The Mod 8 concept plan buildings have significant impact on viewing of the Southern Cross, Alpha-Centauri, the Jewel Box, Omega Centauri and other objects both by way of increased light spill and by blocking the view at certain times of the year.

64 I agree that the Mod 8 concept plan may have an impact; the issue of whether it significantly affects the observatory's operations is subjective, and in terms of light spill, it may marginally degrade what is already a very poor observing site.

65 In terms of obstruction, it will impact on the viewing of the listed sky targets for about two months of each year, but the listed targets will be very low in the sky, and there are many other sky targets of interest far better placed for viewing at that time and would provide a much better observing experience.

66 Apart from the Moon and planets, the following are some suggested alternate interesting sky targets that are better placed in the sky for viewing at that time of year (August-September):

- Constellation of Scorpius,
- Antares (giant red star),
- Butterfly cluster (beautiful open cluster of blue stars),

- Small Sagittarius star cloud (a gap in the dust lanes of the Milky Way that permits viewing of millions of distant stars that reside in a distant arm of our galaxy),
 - Ptolemy's Cluster (a bright open cluster of blue stars),
 - Yed Prior and Yed Posterior (well separated double star),
 - Lagoon Nebula (an emission nebula – a giant star forming region of glowing gas, rather faint but should be OK to view in the Observatory's larger telescopes).
-
- From 12 to 25% of available viewing days and from 6 to 15% of the available viewing time of these iconic objects will be lost if the Mod 8 buildings are constructed.

67 I have not calculated the percentages of lost viewing time as this is somewhat subjective, for the reasons provided in paragraph 57 above.

4.2 RESPONSE TO THE UNSW GLOBAL IMPACT ASSESSMENT

Sydney Observatory was not consulted in the course of the completion of the Report prepared by Mr George Geogevits on behalf of Expert Opinion Services, a business unit of UNSW Global.

68 This is true. However, my instructions stated that Sydney Observatory was consulted prior to the engagement of UNSW Global.

69 This is evidenced by the material contained in the appendix of the first report. Consultations defined the viewing corridors investigated (and which now have been augmented by the observatory).

The Report prepared by UNSW Global states the impacts and functioning of Sydney Observatory due to the Mod 8 Concept Plan 'are negligible'.

70 I disagree – nowhere in my report does it state that the impacts are "negligible".

The detailed assessment indicates:

- Building H1 is excluded from the report. The Crown casino and residential tower is included in the Concept Plan and will impact night sky viewing and will cause light spill.

71 I agree. Building H1 was not part of my brief for the preparation of the first report, as it was not listed by the observatory in their identification of key targets for analysis.

72 I also agree that the Crown Hotel and residential towers as described in the Concept Plan will impact night sky viewing and may cause some light spill.

- The Report is based on information 'determined in consultation with Sydney Observatory' in mid-2013. The data was provided prior to the announcement of the scale of the Barangaroo South Development.

The Report (section 2.1) has misquoted and included erroneous information and interpretation of the viewing corridors provided by Sydney Observatory in November 2013.

The data provided relates to the altitudes and azimuths required to view the Southern Cross, Jewel Box, Alpha Centauri and Omega Centauri.

The view corridors included in the View Impact Assessment were not determined in consultation with Sydney Observatory and represent the principal difference in impact assessment that informs the comments provided in this submission.

73 I am not in a position to comment on this. I prepared the first report on the basis of the brief that was provided to me by Lend Lease.

- Sydney Observatory is in agreement with most of the statements in Section 3.2 and 3.3, excepting those relating to the building H1. The Report uses a mistaken definition of the view corridor, quoted as 210 to 225 degrees (section 3.2). This should be 210 to 235 degrees. The impact of the difference in the Azimuth Range is as follows:
 - (Section 3.3) claims the impact of the 275 metre Crown Casino and Residential Tower (H1) will not obstruct any of the Sydney Observatory view corridors. The H1 Tower will affect viewing of Omega Centauri.
 - The tables and impact times (Section 4.2) for the 250 metre residential tower (R4A) and the 210 metre residential tower (R4B) contain errors. These include viewing times when an object is behind the buildings.

74 The viewing times were calculated using building obstruction data provided as part of the brief.

- The data based on the impact of cloud cover is based on Bureau of Meteorology records made at 9.00am and 3.00pm. These indicate that 50 percent of **days** are affected. Sydney Observatory records the impact of cloud cover on **night** viewing. These records indicate successful night viewing occurs on 70 percent of nights in the months August to October.

75 I only had access to Bureau of Meteorology weather data when preparing my first and second reports, and in my view, it is best practice to use this source to obtain meteorological data in Australia.

76 Successful observing may be possible on 70 percent of nights because it is always possible to view some parts of the sky when partial cloud cover is present.

77 However, it may not be possible to view the target objects in question, depending on the position of individual clouds, so I very much doubt that it is possible to view the four sky targets in question on 70% of nights during August to October, particularly as they are at low altitude and hence have a higher probability of being obstructed by cloud (because we are looking through more air mass at low altitude).

- The Report (section 4.2) claims that the impact of the developments on night viewing can be reduced by changes to the structure and conduct of the night viewing program. This is not an option, for a number of operational reasons. The Building Code of Australia, not the facility, requires group size of maximum 22 people in the existing telescope domes.

The Report claims the viewing schedule can be adjusted to enable the affected targets to be viewed first. This cannot be achieved across multiple groups in the April-September period. To maximise viewing in this period, the program is structured to provide 3 or 4 groups of 20 within a 90 minute period in each session, based on two sessions per night.

78 I am not privy to the observatory's "operation reasons", so I cannot comment on this issue, other than to say that I find it hard to believe that their viewing schedules have no flexibility whatsoever, given that they typically observe only five sky targets during each observing session.

- Smog and Particulate Pollution (section 4.4) as well as scintillation do not impact a public observatory to the same extent as a research observatory. NSW Office of Environment and Heritage Air Quality data indicates a rolling fluctuation in Sydney, which is not increasing.

79 I agree that these factors may not be as important for a public observatory as for a research facility.

80 Nevertheless, the observatory is arguing against a slight degradation in what are already very poor observing conditions, and this issue could be circumvented altogether if the observatory chose other, more suitable, target objects that are at a high altitude at that time of year.

81 This would provide much better image quality and a better user viewing experience, given the significant limitations of the observatory site.

- The Report (section 1.3) refers to concerns expressed by Sydney Observatory about the impact of light spill, in a letter dated June 2011. These comments were in response to Modification 4 of MP06_0162, not the Modification currently on exhibition.

The comments were made when the concept for Barangaroo South included a 170m high casino, hotel and residential tower. The residential hotel/casino is now proposed at 275 metres in height. The emphasis in this letter was on Barangaroo Central, transport, the Headland Park and cultural linkages.

- The lighting impact analysis (Section 5.0) should take into account the 2011 letter and eliminate up-lighting, not use blue lighting and recommend sensor lighting. It does not reference the impact of light spill from the eastern facades of the three residential towers, will likely feature extensive use of glass, to maximise views to the city and Sydney Harbour.

82 I cannot comment on these issues as they are outside the scope of my brief.

- Sydney Observatory is in agreement with the Report (Section 3.1) that Barangaroo Central does not impact the Sun, Moon, Planets, Ring Nebula and Star Albireo.

83 No further comment.

- The Report (Section 6.0) concludes the development will affect '53 viewing nights out of 326 annual viewing nights'. This represents 20% of the night viewing program. The Observatory agrees with this in terms of direct blockage but, because this does not indicate the year-long impact of light-spill from predominantly residential towers, and because the tables are based on seeing part of the Southern Cross as acceptable, the Museum disputes the author's conclusion that this impact is 'negligible'.

84 I reiterate that nowhere in my report does it state that the impact of the Mod 8 buildings is "negligible".

85 The calculation of percentage lost viewing times is subjective, it being dependent on the following factors:

- What is defined as acceptable viewing time.
- How the building outlines are defined.
- What tolerance is allowed for light spill.
- If part of a target is not visible for even part of an observing session, even though it could be observed during another part of the same session, whether it should be considered as lost viewing opportunity.
- Whether a night of partial cloud cover should be included as an acceptable viewing night.
- Whether the nights during Bright of Moon are included in acceptable viewing nights for ω Centauri or other faint targets.
- Whether nights when nearby events use bright lighting (e.g. Vivid Festival), or fireworks events causing heavy particulate pollution (e.g. New Year's Eve, Australia Day, Vivid Festival) are also considered to be acceptable viewing nights.
- The Crown Hotel has an unusual curved shape, so accurate definition of the building silhouette and hence the exact times when any specific target is obscured becomes difficult.
- The observatory has now advised that they sometimes conduct multiple groups per session, and this may impact on the calculation of lost viewing opportunity for the specified sky targets.

- However, such multiple observing sessions cannot all be conducted from North Dome due to space restrictions. I was advised by the receptionist that viewing is sometimes conducted with other telescopes from the courtyard. If they are conducted from the courtyard, the available sky view is very different, due to the presence of trees and the lower altitude of the observing site. Thus, the same view restrictions do not apply. A separate view loss analysis would be required to see what effect the Mod 8 buildings in question have on the sky view from various locations within the courtyard. It is possible that the Mod 8 buildings may not be visible at all from some parts of the courtyard. Similarly, from the courtyard, trees will have a much greater obstruction effect in some directions. I have not investigated this in detail as it has not been part of my brief to date.
- In addition, for practical reasons, such courtyard viewing sessions would have to be conducted with one of the observatory's smaller, portable telescopes. The disadvantages of viewing at low elevations become more important when using a smaller aperture telescope because the image brightness decreases (due to the lower light gathering power of smaller telescopes) and the adverse effects of turbulence increase with decreasing telescope aperture size.

86 I cannot comment further on the effects of light spill from the Mod 8 buildings, other than to say that I am advised that measures will be taken in the design of the buildings to minimise its effects wherever possible.

4.3 DETAILED RESPONSE

1.0 Introduction

2.0 Sydney Observatory Concerns

87 I have not provided commentary on these aspects of the detailed response by
Sydney Observatory, as the issues concerning what correspondence was
provided, when and by whom were outside the scope of my brief.

88 Regarding the azimuth and elevation ranges to be considered, these were
defined in my brief, and I prepared the reports on this basis.

3.0 View Analysis

89 The Sydney Observatory response highlights perceived deficiencies in my first
report in relation to building H1 (the Crown Hotel).

90 Building H1 was not part of the brief for the first report.

4.0 Timing Analysis

91 The timing analysis provided by Sydney Observatory lists in detail the
calculated number of hours and minutes of lost viewing opportunity for each
target object.

92 This analysis was based on a different set of assumptions to that of the
reports that I prepared, so I expect the outcomes to be different.

93 For the reasons given in paragraph 85 above, the assumptions on which any
such analysis is based is subjective.

5.0 Lighting Impact

Sydney Observatory is an astronomical observatory, it is not a research observatory. The location, the atmospheric conditions and the various present constraints do not prevent public observing.

- 94 In my view, the issue is not whether some factor(s) prevent public observing, but rather what sky targets provide the best observing experience during any given month, under what amounts to poor observing conditions caused by a range of site specific factors, including nearby brightly lit city buildings.

The Sydney Harbour Bridge is not the worst source of light pollution. The general aggregate light pollution from the city, and particularly city buildings are the most significant source of light pollution – additional buildings of Mod 8 plan would significantly increase the light pollution effect on Sydney Observatory. The Mod 8 buildings *cannot* have zero “increased light spill effect on Sydney Observatory”.

- 95 I am not so sure about this, if the reflected light from the Bradfield Highway leading up to the Harbour Bridge is included (see Fig 2.10 above, middle left photo).

- 96 The Bradfield Highway approach to the Harbour Bridge is located immediately adjacent to the Sydney Observatory site (see Fig 4.2 below).

- 97 However, given that some existing residential high rise buildings also very close to the observatory and are unlikely to have implemented light pollution control measures (see section 2. above), the effect of these buildings is likely to be similar.

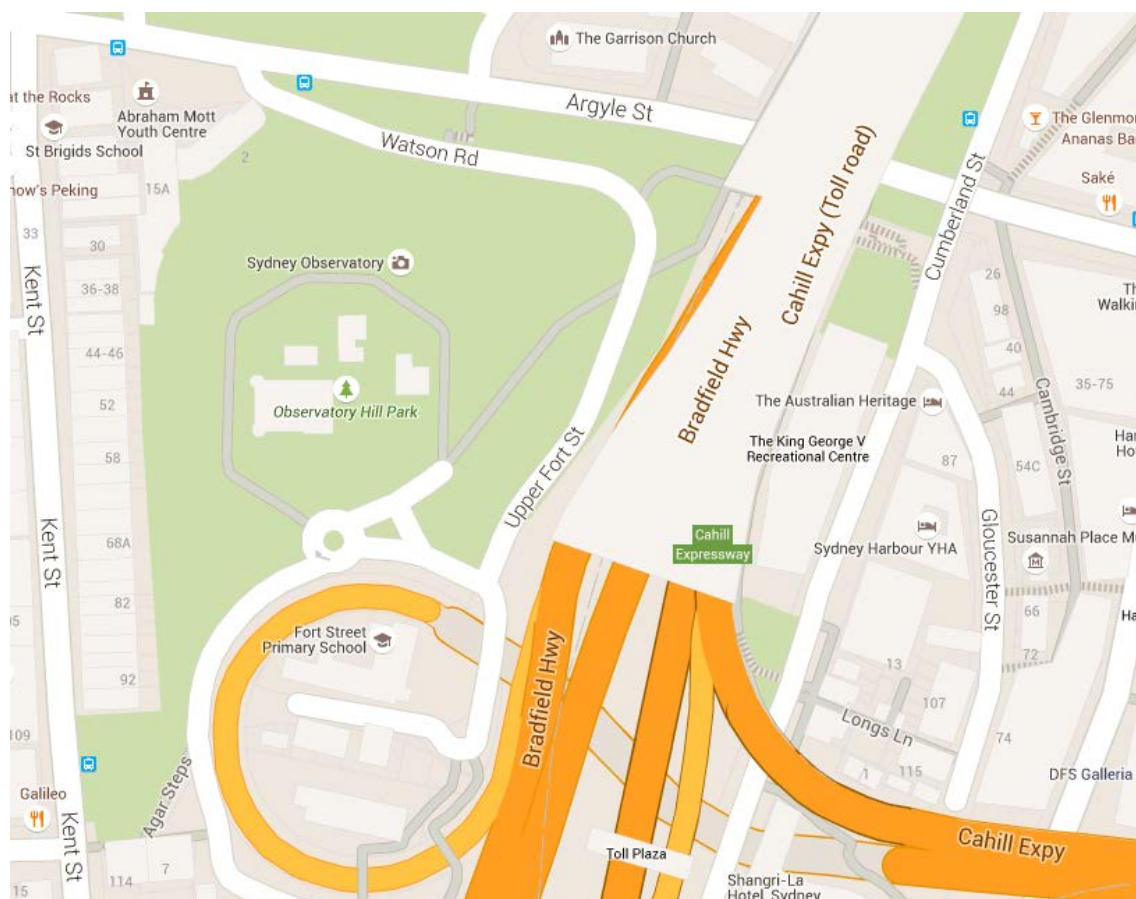


Fig 4.2 - Site map showing the proximity of the Harbour Bridge approach roadway.

6.0 Conclusion

- 98 These relate solely to the content of my first report – building H1 was not part of my brief for the first report.

Overall conclusions

The Mod 8 concept plan buildings have significant impact on viewing of the Southern Cross, Alpha-Centauri, the Jewel box, Omega Centauri and other objects both by way of increased light spill and by blocking the view at certain times of the year. From 12 to 25% of available viewing days and from 6 to 15% of the available viewing time of these iconic objects will be lost if the Mod 8 buildings are constructed.

- 99 Agreed that the Mod 8 buildings have an impact, but the calculated percentage number of viewing days and available viewing times are subjective.

Viewing of alternative objects is not reasonable. The four objects considered here are core objects, the brightest objects of their type and the most visually appealing and educationally effective objects for the public to view. This is the case regardless of how low in the sky these objects are viewed. Sydney Observatory views these objects more than others for these very good reasons.

- 100 Again, this is a subjective issue. The audience for Sydney Observatory would have very little astronomical knowledge or experience with observing. In my view, a lay person would have a better observing experience looking at sky targets high in the sky, where the image quality is relatively good, than at something low down, where weather conditions, turbulence and sky glow degrade the image.

- 101 Regarding suitable sky targets, there are a large number of interesting objects to choose from, and, in my view, the fact that the Southern Cross or some other iconic object is not visible at certain times of the year would not dissuade people from attending observatory viewing sessions. After all, some of the listed objects are not visible for parts of the year, because they are below the horizon. This is part of observational astronomy.

The location of Sydney Observatory, the weather, scintillation, smog and existing light pollution are not relevant to this issue. The issue is the *additional* impact on viewing and *additional* light spill caused by the Mod 8 buildings and Barangaroo South.

102 I agree that the Mod 8 buildings and Barangaroo South will have some impact on viewing from Sydney Observatory.

103 I disagree that it will have a significant effect on their public observing business activities, and Sydney Observatory has not provided any substantiation for this assertion.

The impacts on the functioning of Sydney Observatory by the Mod 8 Concept Plan will not be 'negligible'. The conclusion drawn in the Report is incorrect and not supported by the evidence.

104 I did not say the impact of the Mod 8 Concept Plan is "negligible".

105 The reports I have prepared were done on a factual basis.



George Georgevits
B.E. (Hons)

APPENDIX 1

Sydney Observatory Public Viewing Schedule

9/15/2014

Hours and charges | Sydney Observatory



**sydney
observatory**
PART OF THE POWERHOUSE MUSEUM



Hours and charges

Hours and charges

[Night visit \(online bookings\)](#)

[Night group visit](#)

[Day visit](#)

[Day group visit](#)

[Special events](#)

[School holiday program](#)

[Private telescope viewing](#)

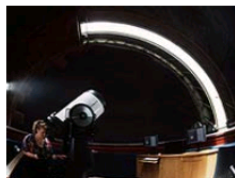
[Booking conditions](#)

[How to get here](#)

[Facilities, food, access](#)

[Birthday parties](#)

[Tourist operators](#)



NIGHT VISIT

Open nightly Monday to Saturday except Good Friday,
Christmas Day and Boxing Day holidays. Open Sunday nights
during school holidays.

Bookings are necessary for night sessions (of approximately 90
minutes duration). Phone (02) 9921 3485 or [book online](#).

Night telescope/3D theatre session times

April to September – 6.15pm and 8.15pm

October and November – 6.15pm

December and January – 8.30pm

February and March – 8.15pm

Night charges for telescope/3D theatre sessions

Adult – \$18

Child (4 to 15 years) – \$12

Concession – \$14

Family (1 adult and up to 3 children;
or 2 adults and up to 2 children) – \$50

Member (adult) – \$16

Member (child) – \$11

Member (family) – \$43

Sessions are held regardless of weather. If viewing through the
telescopes is not possible due to sky conditions, a fun digital
planetarium session is provided instead.

All night visits must be booked and prepaid prior to arrival at the
Observatory. Payment for night tickets is not refundable.
However if you notify us by phone on 9921 3485 by noon on the
day you are scheduled to attend your night visit, we can either
transfer your booking to another available night; or offer you a
'rain check' ticket, valid for three months from first booking, to
the same value as your original booking.

Debit and credit card fees: As part of a NSW Government
requirement, Sydney Observatory applies a surcharge on all
transactions made by debit or credit cards. Surcharge rates are
determined on a cost-recovery basis only. No surcharge is
incurred when paying with EFTPOS, cheque or cash. Payments
made on VISA and Mastercard attract 0.40%

Review your visit on facebook

Would you like to tell others about your visit to Sydney
Observatory? Then you might like to [review your visit on
facebook](#).

DAY VISIT

Open 10am – 5pm daily

except Good Friday, Christmas Day and Boxing Day holidays

Open 10am – noon New Years Eve

Day telescope/3D theatre session times

Monday to Friday (school term) – 2.30pm, 3.30pm and 4.00pm

Weekends and school holidays – 11am, noon, 2.30pm and
3.30pm

Bookings are not required for day sessions.

Day charges for telescope/3D theatre sessions

Adult – \$10

Child (4 to 15 years) or concession – \$8

Family (1 adult and up to 3 children;
or 2 adults and up to 2 children) – \$26

Member adult – \$6

Member child (4 to 15 years) or concession – \$4

Member family (1 adult and up to 3 children;
or 2 adults and up to 2 children) – \$16

Daytime admission for a self-guided visit to the gardens and the
Observatory exhibitions is free – but does not include visits to
the telescope towers, telescope viewings and 3D theatre
sessions.

Debit and credit card fees: As part of a NSW Government
requirement, Sydney Observatory applies a surcharge on all
transactions made by debit or credit cards. Surcharge rates are
determined on a cost-recovery basis only. No surcharge will be
incurred when paying with EFTPOS, cheque or cash. Payments
made on VISA and Mastercard will attract 0.40%

The Powerhouse Museum is an Affiliate of the NSW
Government's Department of Ageing, Disability and Home
Care's Companion Card program. This means that carers who
accompany a person with a disability will be eligible for free
entry on presentation of their Companion Card. For more
information visit www.companioncard.org.au



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[Visit the Powerhouse Museum](#)

1003 Upper Fort St, Millers Point, NSW, 2000.

Bookings / enquiries: PH: (02) 9921 3485

[NSW Government](#)

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email: observatory@phm.gov.au

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APPENDIX 2

Science Article

ASTRONOMY

Twinkling Stars May Reveal Stuff of Early Solar System

Australian researchers say dips in the brightness of stars may tell of a vast array of objects beyond the planets, but others aren't so sure

CATANIA, ITALY—The Kuiper Belt, resting place of much of the detritus left over from the creation of the solar system, may contain many more small objects than previously thought. Australian astronomers scanned the outer reaches of the solar system by looking for a brief dimming of the light of distant stars as subkilometer-sized bodies passed in front of them. Preliminary results presented at a workshop here earlier this month* suggest that huge numbers of such objects lurk beyond the orbit of Neptune. Although most Kuiper Belt researchers are cautious, studies by some other teams suggest the Australians may be onto something. "If this is true, it would be fantastic," says Alessandro Morbidelli of the Observatoire de la Côte d'Azur in Nice, France, because information about the smaller denizens of the Kuiper Belt cannot be found any other way.

Astronomers have found more than 1000 bodies in the Kuiper Belt, including an object known as 2003 UB₃₁₃ (nicknamed Xena) that is slightly larger than Pluto. But because they are several billion kilometers away, even the most powerful telescopes can't see Kuiper Belt objects smaller than about a hundred kilometers across. Researchers are keen to know more about their size distribution, as it would shed light on the early youth of the solar system.

An effort to fill that gap has been going on since last year. The Taiwanese-American Occultation Survey (TAOS) operates three automated 50-centimeter telescopes at Lu-Lin Observatory, Taiwan, which scan starlight for telltale dimming that signals a Kuiper Belt object passing in front of, or "occulting," the star. So far, the survey has drawn a blank. Team member Federica Bianco of the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Massachusetts, says TAOS can't observe very brief dips in brightness, so it is capable of spotting only the relatively rare objects larger than a few kilometers in diameter.

* Trans-Neptunian Objects: Dynamical and Physical Properties, Catania, Italy, 3–7 July.

But George Georgevits and Michael Ashley of the University of New South Wales in Sydney and Will Saunders of the Anglo-Australian Observatory in Siding Spring say the Kuiper Belt may teem with objects too small for TAOS to see. Using a fast detector at the 1.2-meter U.K. Schmidt Telescope in Siding Spring, they saw well over a thousand brief brightness dips, each lasting for a tenth of a second or less, while monitoring dozens of stars for about 2 weeks.

"It's very important work, and they should certainly continue," Morbidelli says. "But the

and check." But Georgevits counters that he has checked and ruled out every other possible cause of the stellar winks.

So are the results real? "Well, it seems they are observing *something*," says David O'Brien of the Planetary Science Institute in Tucson, Arizona, although he adds that no one has yet carried out a detailed statistical analysis of the Australian results. According to O'Brien, collisions in the Kuiper Belt may have produced hordes of small objects. "If confirmed, these results could tell us something about the strength properties of Kuiper Belt objects," he says.

Some other studies support the Australian results. Taiwanese astronomers have uncovered similar brief occultations of the well-known x-ray source Scorpius X-1 in data from NASA's Rossi X-ray Timing Explorer satellite. A team led by astronomer Ping-Shien Wu of the National Tsing Hua University in Hsinchu

presented the finding in April at the Chinese Astronomical Society Taiwan's meeting in Taichung and is due to publish it in *Nature* next month. And at the Catania workshop, Françoise Roques of the Paris Observatory described three brief occultations detected with the 2-meter Bernard Lyot Telescope in the French Pyrenees, which Roques says may also represent small Kuiper Belt objects.

Not everyone is convinced. "They have to do more checks on possible false alarms," says Matthew Lehner of CfA. For instance, the dips might be caused by unknown effects in Earth's atmosphere. To avoid these, you need to observe from space, says Lehner, who is part of a team that has pitched to NASA a \$425 million occultation mission called Whipple, which would detect Kuiper Belt objects as well as comets in the much more distant Oort Cloud.

Meanwhile, Georgevits hopes to raise half a million dollars for a purpose-built ground-based telescope equipped with a very fast video camera. Such a device could survey the whole Kuiper Belt for a fraction of the cost of a space mission, he says. And although his team's preliminary results raised

some eyebrows, everyone agrees on the need for a more comprehensive search. Says O'Brien: "Small Kuiper Belt objects will never be observed directly. Occultation surveys have a lot of potential to fill in this gap."

—GOVERT SCHILLING

Govert Schilling is an astronomy writer in Amersfoort, the Netherlands.



When worlds collide. Two icy bodies crash in the Kuiper Belt in this artist's depiction. Could such collisions have populated the belt with tiny objects?

results so far are very strange," because current theories of the evolution of the solar system do not predict huge numbers of small Kuiper Belt objects. Michael Brown of the California Institute of Technology in Pasadena, who discovered 2003 UB₃₁₃, adds that "the believability factor [of these results] isn't very high. Unfortunately, you can never go back

CREDIT: DAN DURDA/IAAA

APPENDIX 3

Curriculum Vitae

Brief Curriculum Vitae for George Georgevits

1. In 1972 I was awarded a cadetship with the then Postmaster General's Department to complete my Bachelor of Electrical Engineering degree at University of NSW.
2. I graduated in 1974 with honours.
3. I have 40 years experience as an electrical engineer, specialising in the fields of telecommunications, electronics and power.
4. In 1981 I founded Power and Digital Instruments Pty Ltd. (PDI) with a view to establishing a consulting engineering practice specialising in communications and electronics. A brief capability statement for PDI appears in Appendix 4.
5. Through PDI, I have successfully completed thousands of engineering projects for some 300 corporate and government clients.
6. PDI also owns and operates a test and measurement laboratory. The primary function of this laboratory is to conduct a wide variety of electrical tests on various types of active and passive components and equipment using sophisticated laboratory test equipment.
7. In addition, I regularly write technical articles on topical communications and power technology issues for *Cabling Connections*, *Cabling Home Solutions* and *Electrical Connections* magazines, these being Australian trade journals.
8. Although my formal qualifications relate primarily to electrical engineering, I also have extensive experience with the concepts of physics, electromagnetic waves, advanced mathematics and errors in measurements.
9. I am presently undertaking a part-time PhD in Astrophysics at the University of NSW.
10. My work Astrophysics has been cited in an article in the internationally recognised journal *Science* and also referenced in an article appearing in *Nature*.

APPENDIX 4

Capability Statement for PDI

POWER AND DIGITAL INSTRUMENTS PTY LTD.



Electronics and Communications Consulting Engineers

ACH 882 855 763

POSTAL:
P.O. BOX 422
ROSEVILLE NSW 2069

BUSINESS OFFICE:
66A FINDLAY AVE
ROSEVILLE NSW AUSTRALIA

TEL: +61 2 9411 4442

ABN 21 002 065 769

Jan'14

CAPABILITY STATEMENT

FIELDS OF EXPERTISE:

- Data Cabling Systems and Components - Design, Testing and Certification
- Voice and Data Communications and Telephony Technology
- Radio Communications, HF, VHF, UHF and Microwave
- Power Systems, Equipment, Distribution Networks & Providers
- Assessment of Damages Claims for Communications, Power and Gas Infrastructure
- Communications Equipment and Service Suppliers and Carriers
- Lightning Protection, Surge Suppression and Earthing Systems
- Electronics Design, Manufacturing, Test & Measurement and Troubleshooting
- Equipment and Component Testing and Certification
- Computer Networks and Computer Technology
- Project Management and Specification
- Regulatory and Legal Aspects of Power and Communications Systems, Networks and Equipment and Standards Compliance
- Patent Specification Technical Preparation and Advice

SPECIFIC AREAS OF WORK:

- Testing and Certification of Cat 7A, 7, 6A, 6, 5e, 5 and Fibre Optic Components, Cables and Installations to EIA, ISO & Australian standards
- Cat 6A, Cat 6 and Cat 5e Connector Design and Testing
- Optical Fibre Cabling Technologies, including Testing
- Power Systems and Equipment, Cabling, Testing, Magnetic Field Radiation Surveys
- Troubleshooting and Testing Installed Cabling Networks
- Lightning and Surge Protection, System Design and Testing
- Earthing System Design and Testing and Power Co-ordination
- RF Test and Measurement (PDI has a well equipped test lab)
- Radio Interference, Noise, EMC investigations and RF Sweeps for Debugging
- Assessment of Damages Claims for Insurance Purposes
- Troubleshooting Electronics and Computer Circuits and Systems
- Electronics Design, Analogue, Digital and RF
- Electronics Manufacturing and Reliability Engineering
- Specialised Software Development and Interface
- Process Control, Automation, Instrumentation and Data Acquisition
- PABX Systems, Voice Over IP, Key Systems, Mobile and Cordless Telephony

METHODOLOGY

Mr Georgevits has an Honours degree in Electrical Engineering and 38 years experience in the industry as a consulting engineer.

Mr Georgevits is managing director of PDI (established in 1980). PDI has a well-proven track record in engineering consultancy, test & measurement, electronics troubleshooting and computer technology. PDI operates a well-equipped test and measurements laboratory.

PDI has successfully completed thousands of engineering projects for over 300 corporate and government clients.

Consultancy work is carried out primarily by the Principal, Mr George Georgevits. In addition, suitably qualified associates may be called upon from time to time, as required, to meet the specialised demands of particular projects.

ENGAGEMENT

Engagement to perform consultancy work is carried out on a contract basis. Fees may be structured on a fixed lump sum basis for clearly defined tasks, or on an hourly rate for other work, as required and mutually agreed with the Client.

PDI offers a completely independent advisory service. PDI has no affiliations with suppliers of equipment or services.

BRIEF LIST OF REFERENCES

Some Current Assignments:

- Amphenol Canada Corporation (Connector Manufacturer)
- Connection Magazines Pty Ltd (Cabling Magazine)
- Clayton Utz Lawyers
- Knapp AG (warehouse distribution logistics)
- NSW Crown Solicitor's Office
- PRYSMIAN Telecom Cables & Systems Australia Pty Ltd
- QBE Insurance (Aust) Ltd (all states)
- Technical Assessing Pty Ltd (Loss adjusters)
- Thiess Ltd.
- Tyco Electronics, was ADC Communications (Krone)
- University of NSW Communications Services

Some Completed Assignments:

- Acheron Project – James Cameron's Submarine (Avatar & Terminator fame)
- Australian Astronomical Observatory
- Australian National University (ANU)
- Bluescope Steel – Port Kembla Steelworks
- Clipsal Datacomms (Schneider Electric)
- Lantek Electronics – Taiwan (Connector Manufacturer)
- Leighton Contractors M2 Tunnel Widening (Major Projects Contractors)
- Molex Industrial Division (connector manufacturer - US)
- Tenix Group (Major Projects Construction & Defence Contractors)
- Underwriting Agencies of Australia Pty Ltd (Insurance)