COMMERCIAL-IN-CONFIDENCE

Report prepared on behalf of Unisearch Expert Opinion Services
A business of the University of New South Wales

STAR SYDNEY COMPLEX
SYDNEY OBSERVATORY SKY VIEW
LOSS ASSESSMENT

for

Star Entertainment Group Limited (SEGL)
Your reference: Star Sydney Modification 13

by

Mr George Georgevits (B.E. Hons)
Consulting Engineer

Date of Issue: 27 June 2017
Our Reference: J088326

CONTENTS

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 over 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 3), 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 1 and a brief capability statement for PDI is provided in Appendix 2.

1.2 Terms of Engagement

11 I have been engaged by Star Entertainment Group Limited (SEGL) to provide astronomical advice in relation to this matter.

12 The matter entails making an assessment of the possible loss of sky view from Sydney Observatory (north and south domes) as a result of the proposed construction of the Star Sydney Complex (**the Star**) and associated hotel (237.0m AHD (approximate) (232.9 metres from Pirramma Road) (**the Star Tower**), as detailed in the Section 75W modification application (S75W) to be lodged with the NSW Department of Planning and Environment.

13 The S75W modification will include a series of upgrades and expansions to the development onsite approved under Major Project Approval MP08_0098 in 2008.

14 I have been provided with a brief (**the Brief**) that includes a letter of instruction and a copy of the letter from Urbis to NSW Department of Planning and Environment dated 17 December 2015 concerning environmental assessment requirements associated with the Star.

15 As part of the Brief, Urbis have provided me with a set of drawings that show the location of the Star tower and the indicative tower envelope (refer FMJT drawing *Modification 13, 80 Pyrmont Street Pyrmont NSW* , *Overall Elevations Northern Elevation,* Project Code SM13, Sheet No. AF4002, revision P3, dated 19/5/2017).

16 I have also made my own enquiries in relation to certain aspects of this matter.

17 Where I have used material from other sources for this report, I have provided the relevant references.

2. OBSERVATIONAL ASTRONOMY – A PRIMER

18 In the southern hemisphere, the night sky appears to rotate clockwise around a point in the sky known as the South Celestial Pole (see Fig.1).

19 This point represents the intersection of the extension of the southern end of the Earth's axis of rotation with the sky plane (i.e. the plane in the sky perpendicular to the observer's line of sight).

20 Thus the sky plane completes one rotation every 24 hours, which means it rotates at a constant angular velocity of 15^{o} per hour.

21 In order to observe a sky plane object, a telescope must first find the object and then track it as the sky rotates.

22 In addition to this, the Earth moves in its orbit around the sun, completing one revolution approximately every 365.25 days.

23 Thus, at any particular time (e.g. 8:00pm), and at any particular altitude and azimuth (**alt/az**) co-ordinate in the sky plane (e.g. 26^{o}, 210^{o}), a different part of the sky will appear at that co-ordinate location at 8:00pm on each day of the year.

24 Another way of looking at this is that the same part of the sky will now be at another location.

25 For example, on the 1st September, 2014 at 8:00pm, the bright double star commonly known as α Centauri was at alt/az 43^{o}, 216^{o}.

26 On 1st October, 2014 at 8:00pm, it was at alt/az 23^{o}, 213^{o}, the change being due to the fact that the Earth has moved further along in its orbit around the sun.

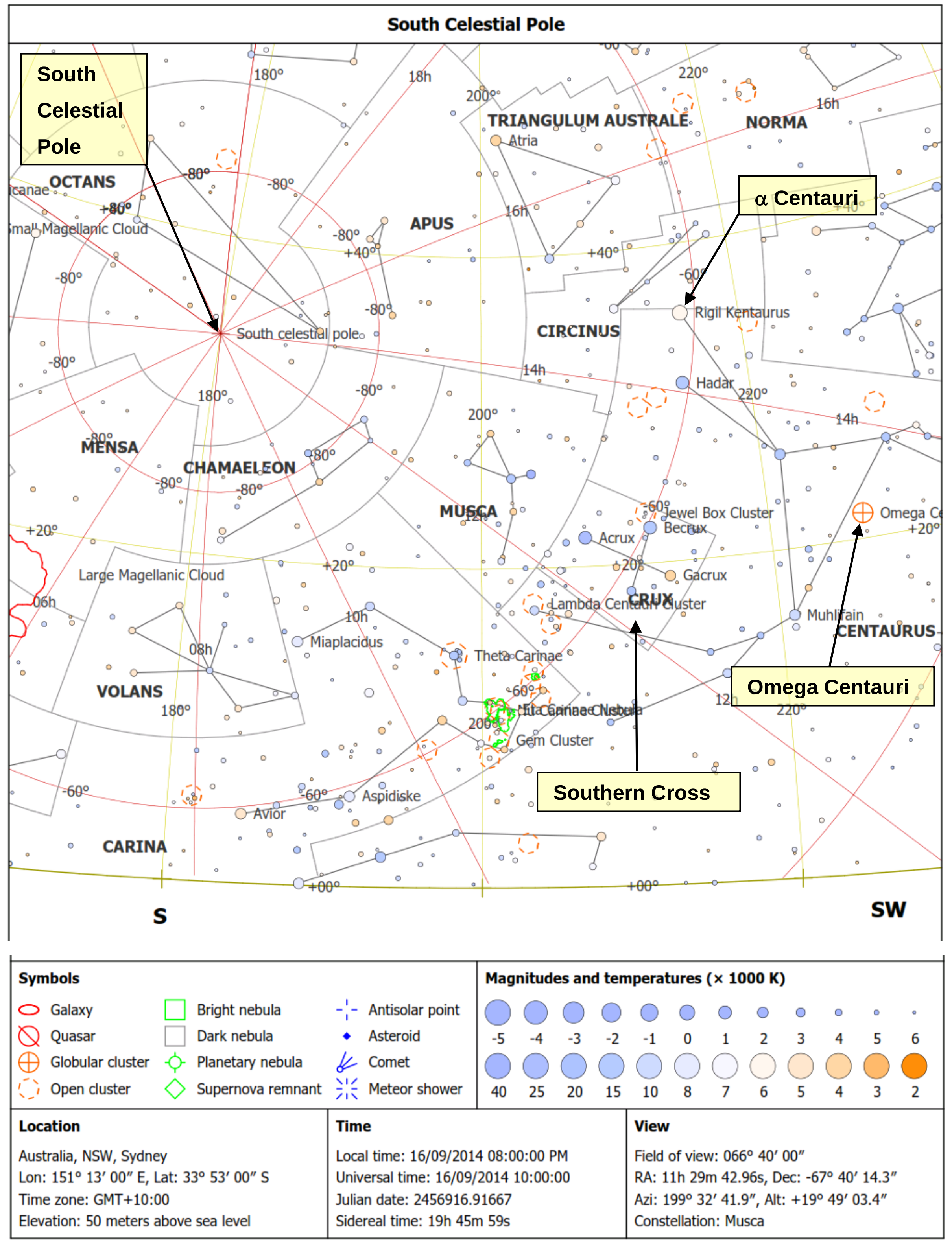


Fig 2.1 Map of the night sky showing the location of the South Celestial Pole and the Sydney Observatory target objects of interest, as they appeared on 16th September, 2014 at 8pm.

3. OBSERVING ISSUES AT SYDNEY OBSERVATORY

27 A number of factors affect the ability to conduct astronomical observations from any particular location.

28 These factors determine whether observing is even possible, and if so, the quality of the image presented by the telescope.

3.1 Cloud Cover

29 Depending on the nature of the clouds, this can degrade the transparency of the atmosphere to the point where it becomes opaque, making observing impossible.

30 With translucent clouds, observing is possible, but scattered light from the various bright city light sources (e.g. Harbour Bridge) will degrade the observed images by reducing the contrast and altering the colours.

31 The Bureau of Meteorology statistics state the following for the weather station at Observatory Hill:

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	
Mean number of clear days	6.8	5.3	7.1	9.1	9.5	9.1	12.0	13.4	10.9	8.1	6.0	6.6	103.9	56	1955 2010
Mean number of cloudy days	13.4	13.0	12.8	10.7	10.8	10.9	8.7	7.7	8.5	11.4	12.5	12.8	133.2	56	1955 2010

Fig 3.1 – 56 year average BOM weather data for Observatory Hill

32 From this, we can assume that there will be a roughly ~50% chance of cloud at any particular time/date at Observatory Hill.

3.2 Smog and Particulate Pollution

33 Smog and particulate pollution affects the transparency of the atmosphere.

34 It causes selective absorption of the short wavelengths of light (blue end of the spectrum), making images look redder (hence the bright orange sunsets during bushfire season).

35 The effect of smog is worse looking at low altitude across the western suburbs of Sydney, and it tends to be worse in summer under certain weather pattern conditions.

36 It can also be bad during bushfires, and during ground cover burn off activities in winter and spring.

37 Smog will also scatter light from nearby bright ground based sources (e.g. Harbour Bridge), thereby increasing the overall sky brightness.

38 These effects will degrade the observed image because the image contrast is reduced and the colours are changed.

3.3 Scintillation

39 Scintillation is caused by air density variations in the atmosphere due primarily to air movement.

40 It results in image distortions that fluctuate with time.

41 Scintillation is also a function of the air mass - the column of air through which the light has to pass.

42 Minimum air mass occurs for targets directly overhead (i.e. at zenith).

43 As we move away from zenith towards the horizon, the column of air we have to look through (and the amount of turbulence it contains) increases.

44 The air mass at 30^o elevation is twice that at zenith (90^o elevation), and therefore the scintillation effects are much worse.

45 These effects then worsen rapidly as the horizon is approached.

46 For example, at 10^o elevation the air mass is six times that at zenith, so the scintillation effects are multiplied six fold.

47 Scintillation effects also worsen with increasing air temperature (heat haze) and with increasing humidity.

3.4 Observing Conditions at Observatory Hill

48 I have personally visited the Sydney Observatory site during the daytime on a number of occasions.

49 However, I have not attended a night time observing session for many years.

50 There are two observing sessions each evening and each runs for approximately 90 minutes.

51 In the summer months, actual astronomical observing using telescopes only occurs during the second session due to the extended hours of daylight.

Fig 3.2 – View of the observatory site looking north, with the South Dome just visible on the left

Fig 3.3 – View of South and North Domes, and courtyard, looking north

52 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.

53 The view from the courtyard is much more restricted at low altitudes than that from the North Dome, due to its lower height and the presence of trees (see Fig 3.3).

54 There are a number of tall city buildings in close proximity to the observatory site (see Figs 3.4 to 3.9).

Fig 3.4 – Close tall buildings, with the Barangaroo development site visible immediately to the right of the cream coloured residential tower. The grey tower on the left also appears to be residential.

55 I have no way of confirming whether light control measures have been implemented in the nearby buildings.

56 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).

57 These cannot be controlled and may emit significant light in the direction of the observatory during observing sessions.

Fig 3.5 – High rise buildings in the background looking approximately south from the observatory courtyard. The grey tower in Fig 3.3 is also just visible on the far right.

Fig 3.6 – Closeup photo of the Highgate building taken from just outside the observatory's North Dome, with the Barangaroo development immediately behind on the right.

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

59 These would all contribute to the unwanted light pollution and background sky brightness.

Fig 3.7 – Looking south from near the North Dome (South dome is at the far right).

Fig 3.8 – Other high-rise light sources looking southeast from the courtyard

Fig 3.9 – Other high-rise light sources looking southeast from outside the observatory grounds

60 These high-rise buildings are all old and presumably have no measures in place to control night time light output.

61 Then 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 3.10 – Sydney Harbour Bridge viewed from Observatory Hill

Fig 3.11 – 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 immediately above the Sydney CBD due to the large number of bright light sources.

62 Special events on and around Sydney Harbour often involve very bright lighting and also particulate pollution when fireworks are involved.

63 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.

64 Thus the background sky is brighter at lower observing altitudes because of the greater air mass in the viewing path.

65 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.

66 For the reason given in Section 3.2 above, the adverse effect of these bright light sources can be minimised by observing sky objects at high altitudes.

4. IMPACT OF THE STAR TOWER ON SYDNEY OBSERVATORY OPERATIONS

4.1 BACKGROUND

67 The Sydney Observatory site is located on Observatory Hill at The Rocks, Sydney NSW, about 600m south west of the Sydney Harbour Bridge.

68 The observatory building was built between 1857 and 1859. It is now part of the Powerhouse Museum.

69 Due to the glare of the city lights (the nearby Harbour Bridge in particular), the low altitude of the site and its proximity to water, seeing conditions are relatively poor at the observatory even on the best nights.

70 Research astronomy has not been conducted at the site for many years now.

71 However, the observatory does conduct public astronomical observing sessions from the North Dome building using a 16” Meade Schmidt Cassegrain telescope.

72 Due to the presence of heritage listed trees in the park surrounding the observatory, the portion of the view from the observatory in the direction of the proposed Star Tower below 18^o elevation is presently obscured (see Figs 3.2 and 4.1).

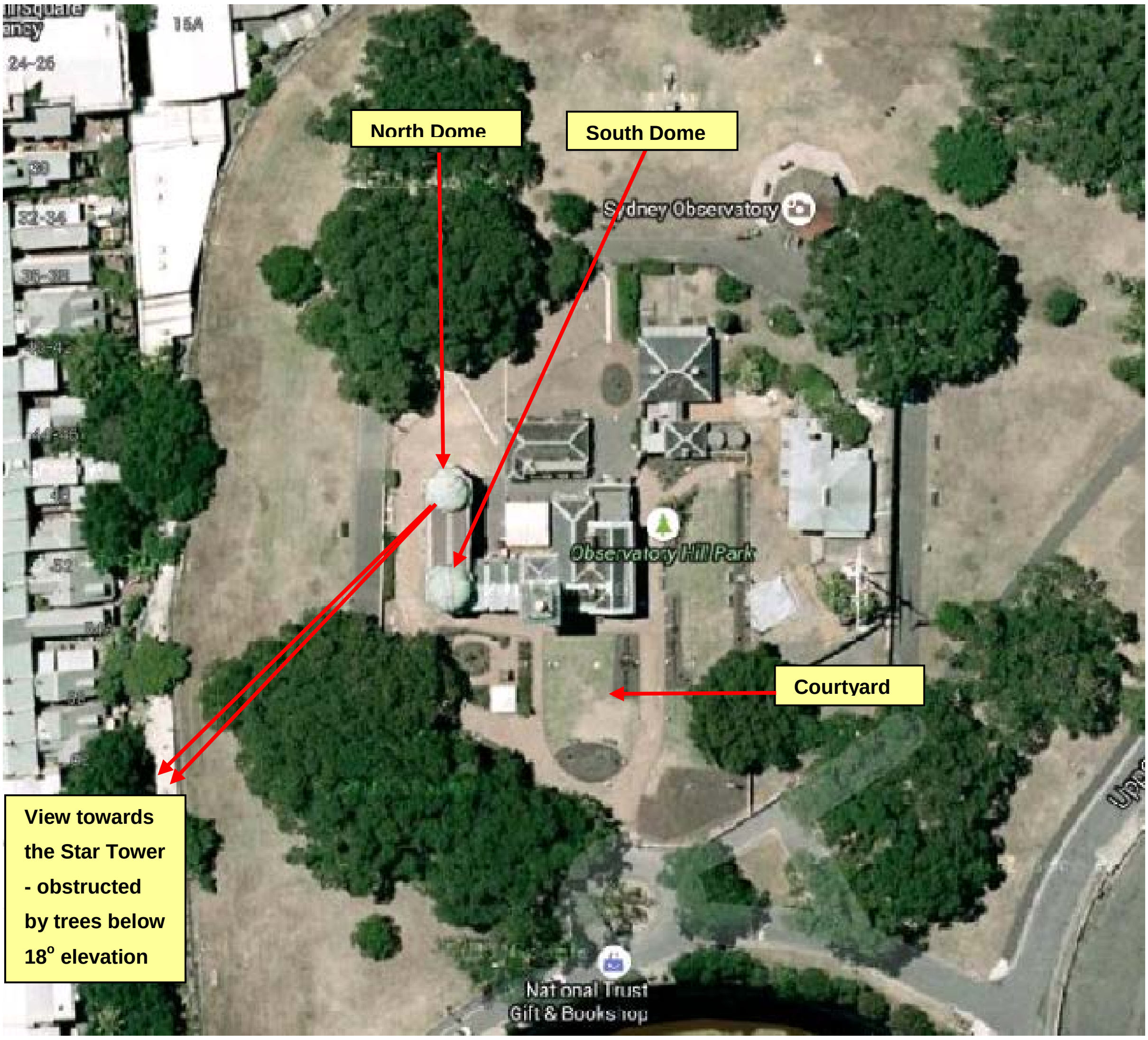


Fig 4.1 – Sydney Observatory site satellite photo showing North and South domes and the courtyard

4.2 Observatory Opening Times

73 The observing times vary, depending on the time of year. The observatory opening hours is provided in Appendix 4.

74 Thus in order to assess the impact on sky view caused by any particular obstruction, the locations of each required target object must be tracked throughout the year so as to determine when or even if it intersects with the obstructed area of sky, and if so, for what proportion of the observatory's opening hours on the days it is open.

4.3 Impact of the Proposed Star Tower on Sky View

75 The proposed Star Tower is located approximately 1160 metres south west of the Sydney Observatory North Dome building.

76 It has a proposed height of 237.0m AHD (approximate) (232.9 metres from Pirramma Road).

77 The top of Observatory Hill is at an altitude of 39 metres and the domes are a few metres above this, which means that the base of the Start Tower is below the horizon by ~1.9^{o} when viewed from the observatory.

78 Consequently, when viewed from the observatory, the Star Tower would obscure a block of sky approximately 2.2^{o} wide (azimuth angle between 224.9^{o} and 227.1^{o}) by 10^{o} elevation above the horizon (see Fig 4.2 below).

79 Thus the Star Tower will have no observational impact on the operations of the Sydney Observatory due to the presence of the trees.

4.4 Impact of Star Tower if Trees Not Present

80 As the trees are not a permanent fixture, I now consider the case where the trees are not present.

81 The observatory had previously indicated interest in observing the following night sky objects:

- The Southern Cross
- The Pointers
- The Jewel Box Cluster (open star cluster)
- ω Centauri (globular star cluster)

82 At a certain time of the year, these objects all pass through the area of sky in the vicinity of the block of sky obstructed by the Star Tower.

83 At 10^o elevation (corresponding to the top of the area of possible sky obstruction by the Star Tower), the observational degradations caused by scintillation, air pollution and sky glow (see Sections 3.2 to 3.4 above) would degrade the view so much as to make observing at such a low elevation angle:

- very poor for the Southern Cross and the Pointers (these bright objects are best viewed by naked eye or field glasses, because they are too widely separated to fit into the field of view of an astronomical telescope)

- not viable for the Jewel Box cluster and ω Centauri, these being fainter and smaller objects that can only be seen well through a telescope.

84 Furthermore, an analysis of the movement of these objects across the night sky shows that they all pass well above and to the left of the block of sky obstructed by the Star Tower, as shown in Fig 4.2 below.

85 The closest approach of these objects to the Star Tower obstructed area of sky occurs at about 8pm during early October each year.

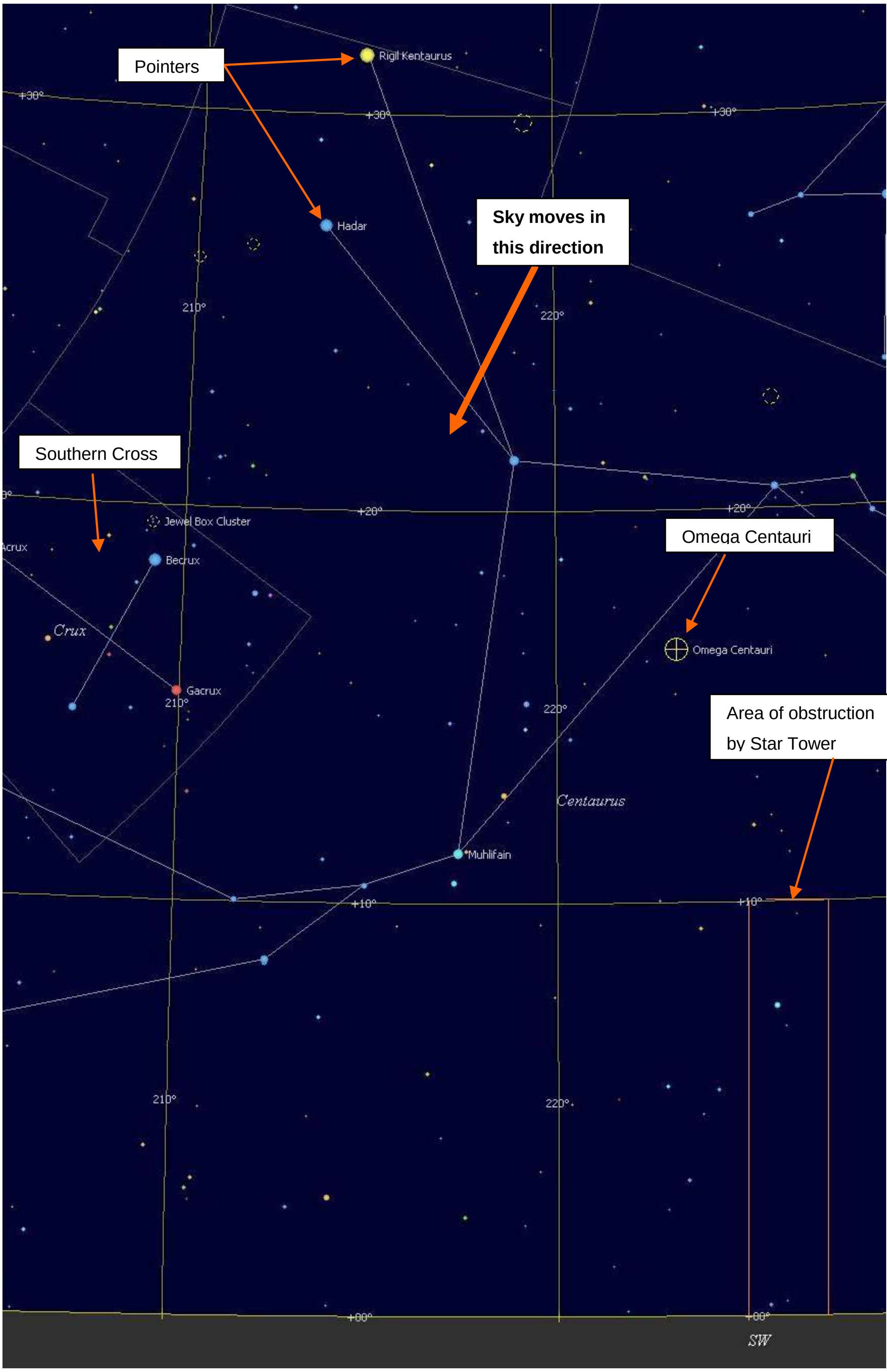


Fig 4.2 – Sky view showing the approximate area of sky obstructed by the Star Tower (red outline), the closest approach by the night sky objects of interest and the direction of sky rotation

5. CONCLUSIONS

86 The Star Tower will have no observational impact on the operations of the Sydney Observatory due to:

- the presence of the trees that obstruct the view of the Star Tower from Sydney Observatory
- the fact that the sky objects of interest nominated by the observatory will not pass through the block of sky obstructed by the Star Tower.

87 Even if the desired sky objects were visible in the general direction of the Star Tower, they would be close to the horizon and this, plus the presence of many nearby strong man-made light sources, would mean that the viewing experience would be very poor.

88 There are literally hundreds of other interesting, better placed, objects in the night sky that are suitable for viewing with a moderate size telescope.

89 At the time of year when the abovementioned objects of interest are low in the sky, 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 (i.e. at higher elevation).

George Georgevits (B.E. Hons)
Consulting Engineer

APPENDIX 1

Curriculum Vitae

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 over 40 years experience as an electrical engineer, specialising in the fields of telecommunications, electronics and power.

4 During the first eight years of my career, I worked as an engineer for the PMG's Department, later known as Telecom Australia and then as Telstra.

5 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 A2.

6 Through PDI, I have successfully completed thousands of engineering projects for some 300 corporate and government clients.

7 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.

8 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.

9 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.

10 I am presently undertaking a part-time PhD in Astrophysics at the University of NSW.

11 I have given presentations of my work in Astrophysics at a number of international and Australian conferences.

12 I have co-authored a Chapter in a textbook on the outer solar system.

13 My work in Astrophysics has been cited in an article in the internationally recognised journal *Science* and also referenced in an article appearing in *Nature.*

APPENDIX 2

Capability Statement for PDI

POWER AND DIGITAL INSTRUMENTS PTY LTD.

Electronics and Communications Consulting Engineers

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

Jun'15

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 & Service Providers
- Assessment of Damages Claims - Communications, Power, Gas & Water Infrastructure
- Electrical fire investigations
- 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

SOME 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
- Electrical fire examinations and equipment testing to determine source of ignition

METHODOLOGY

Mr Georgevits has an Honours degree in Electrical Engineering and over 40 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 some 400 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
- NSW Crown Solicitor's Office
- Omega Power Eqpt Pty Ltd.
- PRYSMIAN Cables 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) – Lightning protection design & test at Mt Stromlo
- 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)
- Surtec Industries Inc. – Taiwan (Connector Manufacturer)
- Tenix Group (Major Projects Construction & Defence Contractors)

APPENDIX 3

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 UB_{313} (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.

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 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 UB_{313}, adds that "the believability factor [of these results] isn't very high. Unfortunately, you can never go back 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.

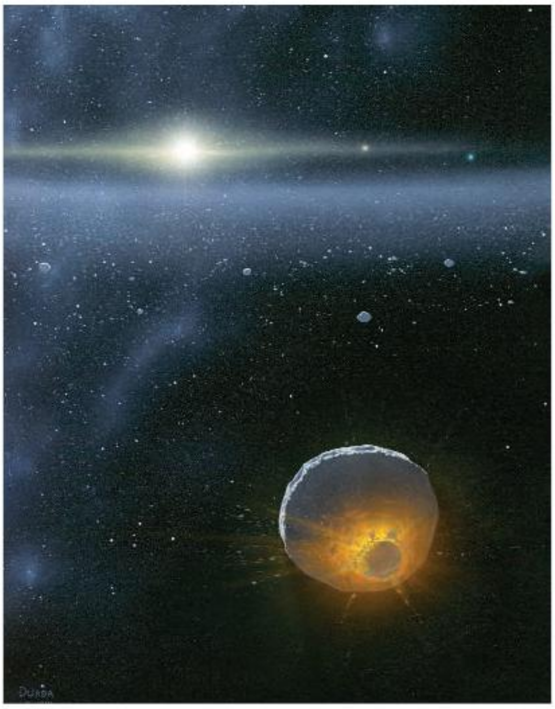
Some other studies support the Australian results. Taiwanese astronomers have uncovered similar brief occultations of the well-known x-ray source Scorpius X-1 in data from NASA's Rossi X-ray Timing Explorer satellite. A team led by astronomer Ping-Shien Wu of the National Tsing Hua University in Hsinchu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

CREDIT: DAN DURDA/FIAAA

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

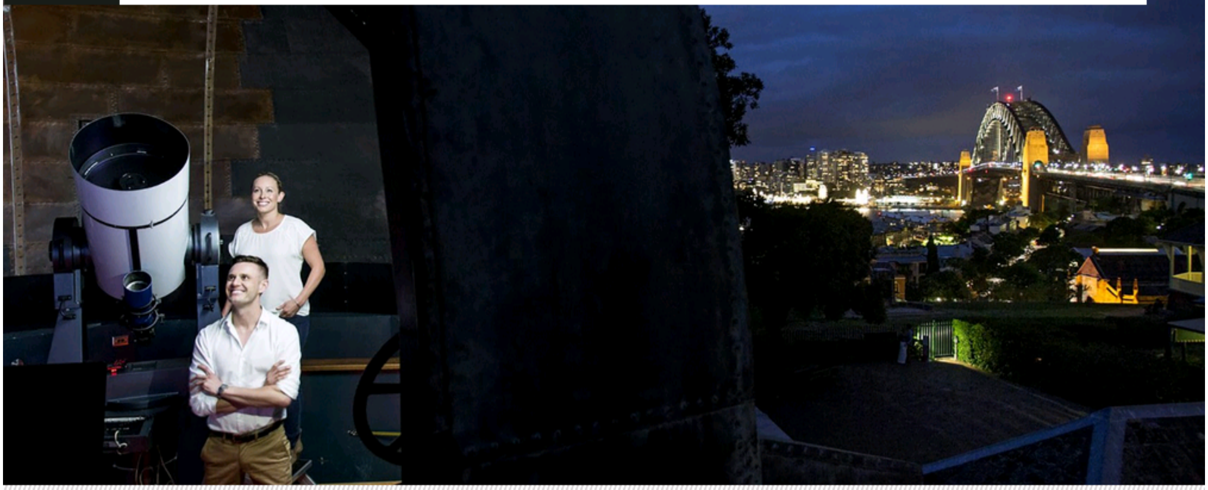
APPENDIX 4

Sydney Observatory Public Viewing Schedule

Museum of Applied Arts & Sciences

POWERHOUSE MUSEUM | SYDNEY OBSERVATORY | MUSEUMS DISCOVERY CENTRE

What's On | Visit | Learn | Join & Support | Collection | Store



Sydney Observatory Night Tours

All year round

The quintessential way to visit Sydney Observatory

In the 19th and early 20th centuries, the Observatory was essential to shipping, navigation, meteorology and timekeeping as well as to the study of the stars seen from the Southern Hemisphere. The Government Astronomers worked and lived in the building until 1982 when Sydney Observatory became part of MAAS.

Today the Observatory is a museum and public observatory with an important role in astronomy education and public telescope viewing. Additionally, Sydney Observatory is located near the historic Rocks district and the world-famous Sydney Harbour Bridge, and is easily accessed by bus, train, ferry or car. A Sydney Observatory telescope viewing of the night sky is a special experience.

Our 8:15pm night tour lasts 2 hours and starts at twilight year round. The tour includes the Planetarium, telescope viewing (weather permitting)*, dome tour and free time to explore the gift shop and historical exhibition. Please be on time as the tour starts from inside the Observatory building shortly after the doors open. Night visits need to be booked and pre-paid. Bookings, including group bookings, can be made up to three months in advance online or by calling Sydney Observatory (02) 9217 0111.

Starting Times

All year round 6:15pm† and 8.15pm

† The 6.15pm tour is designed for family groups and can be booked here.

* Tours are held regardless of the weather. If viewing through the telescopes is not possible due to sky conditions, other activities will be arranged. Tickets are non-refundable but may be exchanged or rain checked for patrons who contact the Observatory prior to 12 noon on the day of their tour.

Terms and conditions are available here.

Venue

Sydney Observatory
1003 Upper Fort Street, Millers Point NSW 2000

More Info

Tickets

Monday–Thursday
Family*: $60
Adult: $20
Concession: $18
Child**: $16

MAAS Members
Monday–Thursday
Family*: $50
Adult: $18
Child**: $14

Friday–Saturday
Family*: $65
Adult: $22
Concession: $20
Child**: $17

MAAS Members
Friday–Saturday
Family*: $55
Adult: $20
Child**: $15

*Two adults and two children / one adult and three children.
** All children must be accompanied by an adult.