Australian Spectrum Consultants Pty Ltd

Public Version

Independent Expert Report

For submission to the Australian Competition and Consumer Commission

Prepared by

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Managing Director

30 September 2005

1. I am the Managing Director of Australian Spectrum Consultants Pty Limited. A copy of my curriculum vitae is at **Appendix A** to my report.

2. Allens Arthur Robinson have instructed me to prepare an independent expert report for submission to the Australian Competition and Consumer Commission (ACCC).

3. I have read and understood the contents of the Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia supplied to me by Allens Arthur Robinson. I agree to be bound the contents of those Guidelines. A copy of the Guidelines (and Explanatory Memorandum) appears as **Appendix B** to this report.

4. In preparing my report, I have had regard to the documents set out in **Appendix C** which have been sourced by me. I have also sourced information from the organisations listed in **Appendix D**.

5. A number of documents set out in **Appendix C** include material that has been deemed by the authors to be 'Commercial-in-Confidence'. Where this material has been used in my report the relevant paragraph, table or diagram has been marked Confidential. The authors have specifically asked that such information not be disclosed outside the ACCC without their express permission.

My instructions

6. I have been asked to address the following questions based on my training, study and experience and the documents that I have independently sourced.

1. Suitable satellites

1.1 What technical and physical characteristics must a satellite and its transponders have in order to be capable of being used to provide subscription television services to Australian customers?

1.2 Which satellites (either current or planned) have these characteristics?

2. Capacity

2.1 How much capacity on these satellites is available now which is suitable to provide subscription television services? How much suitable capacity will be available in the future?

2.2 How many subscription television channels can be provided using a typical satellite transponder?

2.3 What is the typical cost of licensing satellite transponder capacity?

3. New satellites

3.1 Can an entity launch a new satellite now or in the future capable of being used to provide subscription television services to Australian customers? If so:

(a) what will it have to do in order to do so and how much will this cost; and

(b) how much time will have to elapse between the decision to launch a satellite and the provision of subscription television services?

4. Satellite modifications

Assume that a FOXTEL subscriber:

- receives the FOXTEL service from the Optus C1 satellite at orbital slot 156ºE;
- has the following satellite reception equipment: a dish between 65cm and 85cm with one low noise block downconvertor only; and
- wishes to also receive an additional subscription television service from one of the satellites referred to in Question 1.2 (other than the Optus C1 satellite).

For each of the satellites referred to in Question 1.2:

4.1 What modifications would have to occur to the subscriber's satellite reception equipment in order for the subscriber to receive a subscription television service from that satellite as well as continuing to receive the FOXTEL service from the Optus C1 satellite?

4.2 How much would these various modifications cost (excluding labour)?

Assumptions

7. In preparing this report, I have assumed that the information contained in the documents set out in **Appendix C** is accurate and correct. Where I have made other assumptions, I have identified these in the body of my report.

1. Suitable satellites

1.1 What technical and physical characteristics must a satellite and its transponders have in order to be capable of being used to provide subscription television services to Australian customers?

1.2 Which satellites (either current or planned) have these characteristics?

Answer to question 1.1

8. Satellites offer a highly efficient means of delivering subscription television to customers spread over a large geographic area. For example, a single satellite in geostationary orbit (GSO) located over the equator is capable of providing high quality digital television to small dishes at customer premises anywhere on the Australian continent.

9. For some 20 years satellites have provided direct-to-home (DTH) television to Australian households. Initially these (non subscription) services were analogue but in the late '90s evolved to digital modulation using the European developed Digital Video Broadcasting-Satellite (DVB-S) standard. DVB-S offered improved performance, increased numbers of channels and additional features not available on the earlier analogue services and is now used by all Australian DTH services.

10. The successful delivery of a subscription television service via satellite requires the satellite system to meet a number of technical and physical characteristics. These include the location of the satellite, its 'downlink' operating frequency band, the strength of the satellite signal over the target geographic region (i.e. its coverage or 'footprint') and the specification of the satellite 'transponders'.[1] In the reverse direction the performance of the

satellite ground facilities and 'uplink' will equally play a part in determining the ultimate quality and availability of the service received by the DTH customer base.

[1] *Satellite transponders receive the uplink (Earth-to-space) signals from a ground station, amplify them and transmit the signals back to earth in the downlink (space-to-Earth) frequency band. The bandwidth of transponders used for DTH is often 36 MHz although other bandwidths are possible.*

11. Some specific satellite characteristics that are essential to the operation of a DTH subscription television service in Australia are:

- **GSO orbit location**

12. GSO satellites are located in a band over the equator, approximately 36000 km out in space. At this height they essentially remain in a stationary location with respect to the earth. Even so, GSO satellites need to regularly use fuel to maintain station keeping[2] accuracy and this is a significant factor in determining the ultimate 'life' of the satellite. Recent satellites typically carry enough fuel to maintain their orbit position for about 15 years.

[2] *For operational reasons GSO satellites need to accurately maintain their orbital position, i.e. 'keep station'. To counteract the combined gravitational effects of the sun, moon and earth a typical satellite will use fuel thrusters to stay fixed at its precise position over the earth (say within +/- 0.05º of its authorised position over the earth, in both latitude and longitude).*

13. Before 'end of life' is reached the satellite operator will need to have a replacement satellite positioned at the same orbital location to avoid the need for customers to have to re-point their DTH dishes. In some situations it might also be possible for DTH service to continue (perhaps for some years) even though station keeping fuel is running out. Satellites in this situation are referred to as being in 'inclined orbit' i.e. they remain at their nominal location but with less absolute precision.

14. For a GSO satellite to be able to be 'seen' by customers spread widely across the Australian continent it needs to be located somewhere within the approximate range 90E to 180E longitude. Outside this range the 'look angle' to the satellite will generally be too low, i.e. customer dishes (in at least part of Australia) may have to be pointed so low in the sky that local terrain blockage will be a problem.

15. Within the nominal 90E to 180E range there are currently many Ku band satellites serving Australia and others are planned for the short term. Table 1 shows most of these systems:

Operator	Satellite	Orbit location
New Skies	**NSS-6**	**95E**
AsiaSat	**AsiaSat-3S**	**105.5E**
Measat	**Measat-2**	**148E**
Optus	**B3**	**152E**
FOXTEL	***BSS (planned)***	***152E***
Optus	***D2 (planned)***	***156E***
Optus	**C1**	**156E**
Optus	**B1**	**160E**
Optus	***D1(planned)***	***160E***
PanAmSat	**PAS-8**	**166E**
PanAmSat	**PAS-2**	**169E**
PanAmSat	***PAS-30 (planned)***	***170E***

Table 1: Orbit locations of some Ku band satellites serving Australia. There are other systems which could potentially cover parts of Australia if their Ku beams were re-pointed (eg various Intelsat satellites) but these have not been included.

- **Frequency bands, service allocations and licensing**

16. The lifeblood of any DTH satellite is the radio frequency spectrum which it uses. Spectrum is used to connect the satellite to large earth stations that feed it multiple channels of programming material and to simultaneously transmit the material back to the DTH population. Frequency bands used by satellites are often designated by alpha character designators, eg L, C, Ku and Ka. In the space-to-Earth direction the Ku band covers the frequency range 10.7-12.75 GHz and supports satellite downlinks belonging to both the Fixed Satellite Service (FSS) and the Broadcasting Satellite Service (BSS). The FSS occupies the 10.7-11.7 GHz and 12.2-12.75 GHz frequency segments, while the BSS uses the 11.7-12.2 GHz range. Companion Ku band Earth-to-space FSS uplinks operate in the 12.75-13.25 GHz and 13.75-14.8 GHz range, while uplinks supporting the BSS usually operate in the 17.3-18.1 GHz band.

17. Australian DTH satellite services have traditionally utilised the Ku frequency band and this continues to be the band of choice for subscription television services, both here and around the world. The Ku band allows the use of

small receive dishes (often as small as 60-65 cm) which perform well and are relatively easy to install at customer premises. The band also has sufficient bandwidth (typically 500 MHz in each direction) to support large numbers of high powered satellite transponders and consequently large numbers of channels for subscription customers.

18. Although Ku band subscription television services could (subject to licensing) use either unplanned FSS or planned BSS frequency spectrum[3], Australian DTH services have until now used the FSS bands (specifically the 14-14.5/12.25-12.75 GHz segments) as these have offered perceived additional flexibility over use of the planned BSS bands. While the pros and cons of the FSS and the BSS can always be debated, it is noteworthy that both Optus and FOXTEL are planning future systems which will utilise the 11.7-12.2 GHz planned BSS spectrum (at 156E and 152E, co-located with FSS systems). See: *http://www.acma.gov.au/ACMAINTER.2883838:STANDARD:335174966:pc=PC_533*

[3] *The International Telecommunication Union (ITU) Radio Regulations designate certain Ku band spectrum as' BSS planned bands'. The BSS plans provide specific GSO orbital slots for each administration to use, without further frequency coordination; Australia's planned BSS slots being 152E and 164E. The 'unplanned FSS bands' are a popular alternative for DTH services, both in Australia and worldwide, as administrations are free to choose their orbital locations to optimally cover their target audience. While this flexibility is desirable, the chosen orbital slots need to be frequency coordinated with other administrations and this can take some years.*
Further information on service allocations, frequency bands and the international and Australian regulatory landscape can be found at:

http://www.acma.gov.au/ACMAINTER.2883838:STANDARD:335174966:pc=PC_1619

19. Any DTH satellite subscription service wishing to provide service to Australian customers needs to be authorised by a licence issued by the Australian Communications and Media Authority (ACMA), previously ACA. As with all satellite systems, but particularly with the unplanned FSS bands, the ACMA will ensure that international frequency coordination requirements have been met before issuing a licence[4] to an applicant wishing to operate a DTH service to the Australian population.

[4] *Both Australian and foreign satellite operators require a licence to operate an Australian DTH service.*

20. While the unplanned FSS allocations have been favoured by Australian DTH operators to date, in 2001 the ACMA used an auction to decide the allocation of Ku band BSS licences. FOXTEL was subsequently issued with a licence to operate a subscription television service in the planned BSS Ku frequency band from orbital slot 152E. A planned BSS slot remains available at 164E, and there is also a vacant planned[5] (and unplanned) FSS slot at 144.1E. Table 2 indicates Ku band satellite systems currently serving Australia, together with proposed systems. Only some are capable of delivering a DTH service (see satellite characteristics below).

[5] *Planned FSS Ku bands are 10.70-10.95 and 11.2-11.45 GHz (↓) and 12.75-13.25 GHz (↑). Worldwide, the planned FSS bands have not been popular with DTH operators due to the need to coordinate with terrestrial fixed services. Hence the ACMA action to file for unplanned FSS use at this location.*

Operator	Satellite	Orbit location	FSS/BSS	Freq bands (GHz) (↑=uplink, ↓=downlink)
Optus Networks	B1	160E	FSS	14-14.5 (↑), 12.25-12.75 (↓)
	B3	152E	FSS	14-14.5 (↑), 12.25-12.75 (↓)
	C1	156E	FSS	14-14.5 (↑), 12.25-12.75 (↓)
	*D1**	*160E*	*FSS*	*14-14.5 (↑), 12.25-12.75 (↓)*
	*D2**	*156E*	*BSS*	*17.3-17.8 (↑), 11.7-12.2 (↓)*
PanAmSat	PAS-2	169E	FSS	14-14.5 (↑), 12.25-12.75 (↓)
	PAS-8	166E	FSS	14-14.5 (↑), 12.25-12.75 (↓)
	*PAS-30**	*170E*	*FSS*	*14-14.5 (↑), 12.25-12.75 (↓)*
New Skies Satellites	NSS-5	183E	FSS	14-14.5 (↑), 10.95-11.20, 11.45--11.95, 12.50- 12.75 (↓)
	NSS-6	95E	FSS	13.75-14.5 (↑), 10.95-11.20, 11.45-11.70, 12.50-12.75 GHz (↓)
Measat	Measat-2	148E	FSS	13.75-14.5 (↑), 11.45-11.7 (↓)
AsiaSat	AsiaSat-3S	105.5E	FSS	14-14.5 (↑), 12.25-12.75 (↓)
	AsiaSat-4	122.2E	FSS	14-14.5 (↑), 12.25-12.75 (↓)
FOXTEL	*	*152E*	*BSS*	*17.3-17.8 (↑), 11.7-12.2 (↓)*
ACMA auction	*Future*	*164E*	*BSS*	*17.3-17.8(↑), 11.7-12.2 (↓)*
	Future	*144.1E*	*FSS*	*14-14.5 (↑), 12.25-12.75 (↓) plus 'planned FSS' bands*

Table 2: Service allocations and frequency bands of some Ku band satellites currently serving, or planning to serve, Australia. Downlinks in the 10.95 to 11.7 GHz band are less attractive for DTH services as they require coordination with terrestrial fixed services.

** planned system*

21. In summary, satellite systems used to deliver subscription television services to Australia require access to suitable (Ku band) spectrum. The satellite operator also requires a licence from the ACMA authorising the satellite service.

- **Satellite characteristics**

22. To successfully deliver a Ku band satellite based DTH subscription television service to Australian customers it is necessary for the satellite to meet certain technical characteristics. These include:

i. **Signal strength/coverage**

23. The signal from the satellite must be strong enough to deliver a high quality signal to the target DTH receiver population for a desired percentage of time (typical DTH services, using standard DTH signal characteristics, are often designed to be 'available' for around 99.9% of the time, taking into account known rainfall statistics in the target region.) The strength of the satellite signal is usually shown as a series of equivalent isotropically radiated power (EIRP) contours on a map, allowing one to determine the required dish size at the wanted location. For example, if the target population was Sydney, a satellite EIRP in the order of 50 dBW would be necessary to achieve this level of availability into 60 cm dishes with typical signal parameters and expected rainfall patterns[6]. If 90 cm dishes were used, the EIRP would need to be around 46 dBW. Other locations, with higher rainfall statistics, or with less satellite EIRP, would require larger dishes to achieve the same level of availability.

[6] *At Ku band the signal received at the DTH dish can be significantly reduced by heavy rain. This rainfall attenuation is typically allowed for by specifying more EIRP than is necessary in 'clear sky' conditions and by using 'forward error correction' (FEC) in the uplink/downlink signal.*

24. By way of example, Figure 1 below illustrates the Ku band national beam EIRP available from the Optus C1 satellite at 156E. This satellite, using this beam, currently delivers DTH subscription television throughout Australia. The strength of the signal, around 51 dBW in the major population centres, has

been designed to be strongest in these locations to support small DTH dishes (65 cm in many areas) and accommodate known rainfall patterns.

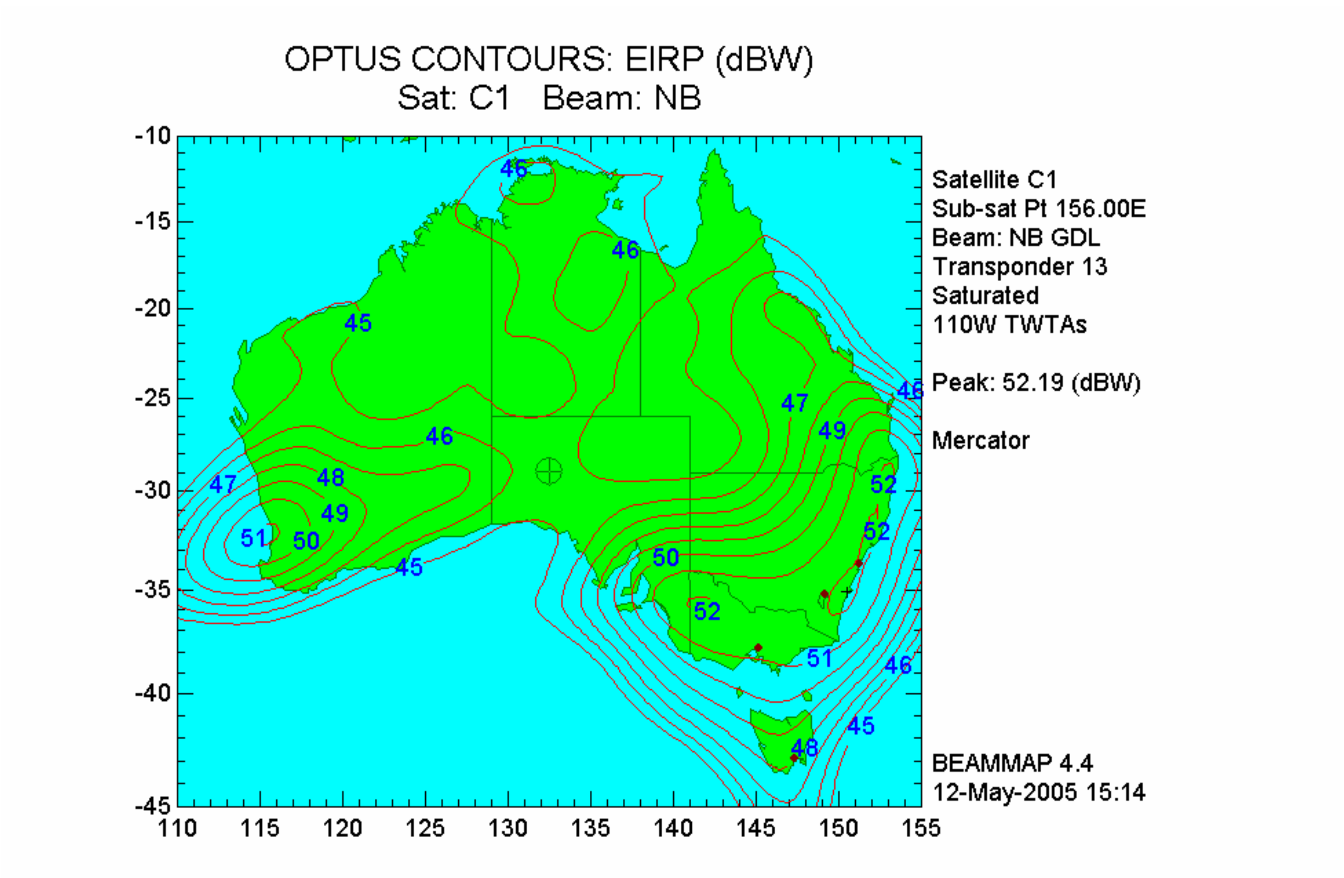

Fig 1: Downlink EIRP from Optus C1 satellite at 156E. Source: Optus document "EIRP Contours", May, 2005.

ii. Capacity

25. The satellite system will need to accommodate the capacity requirements of the subscription television service, i.e. the required number of program channels, at both start up and as the business expands. Typically, satellite transponders used for DTH services have a 36 MHz bandwidth (27, 54 and 72 MHz transponders are also available) and are capable of accommodating MPEG-2 compressed DVB-S type signals with multiplexed data streams approaching 30 Msymbols/s. At this data transmission rate, using standard QPSK modulation and 3/4 FEC[7], it is possible for the satellite transponder to support a combined program and network overhead bit rate of almost 40 Mbits/s. If higher FEC is employed the satellite useable bit rate will fall (eg 2/3 FEC will reduce the useable bit rate to around 35 Mbits/s).

[7] *FEC (Forward Error Correction) is a technique used to improve reception of the transmitted data, particularly during rainfall. As FEC involves the transmission of redundant bits, to correct errors in the data stream, the capacity of the channel is reduced. ¾ FEC is often used for Australian DTH services.*

26. Figure 2 shows the transponder arrangements of the Optus C1 satellite. This satellite has 20 Ku band transponders (of the available 24) providing service to Australia, 16 of 36 MHz and 4 of 72 MHz bandwidth. The majority of the transponders on this satellite are currently used to support Australian DTH subscription television services.

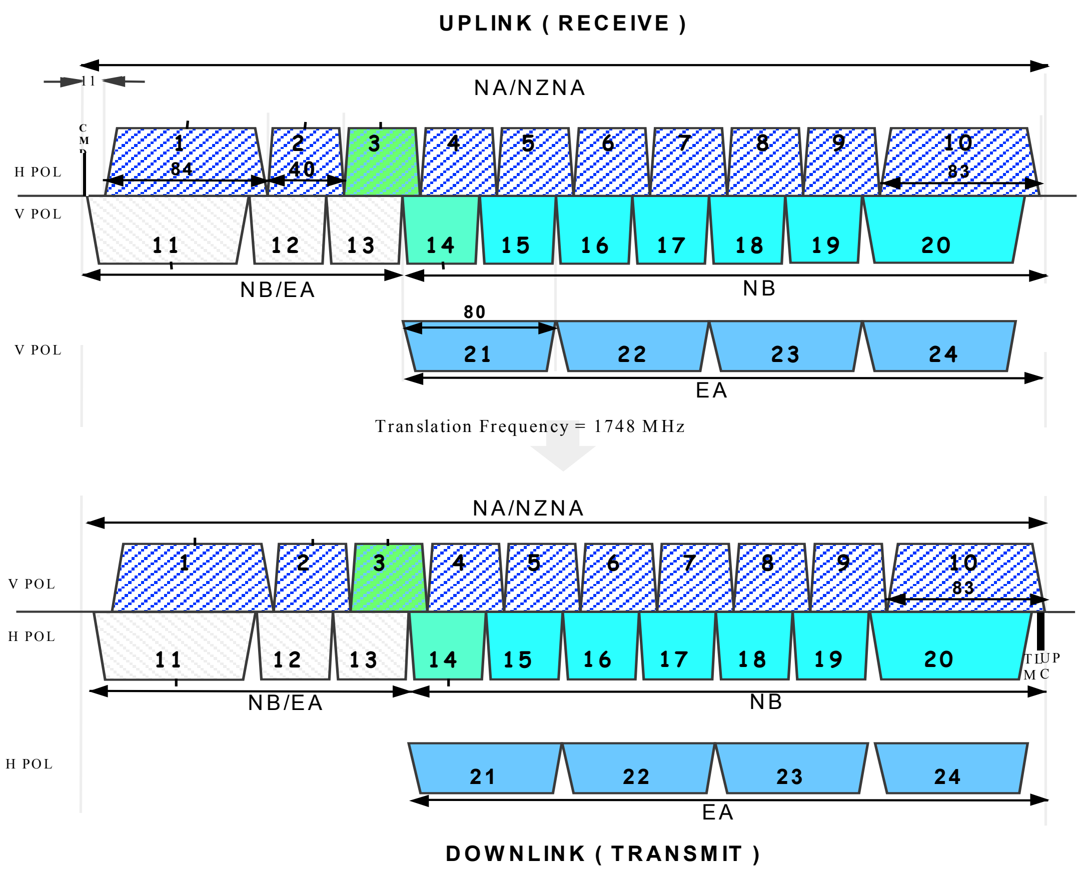
UPLINK (RECEIVE)
NA/NZNA
H POL
V POL
1
84
2
40
3
4
5
6
7
8
9
10
83
11
12
13
14
15
16
17
18
19
20
NB/EA
NB
80
21
22
23
24
EA
Translation Frequency = 1748 MHz
NA/NZNA
V POL
H POL
1
2
3
4
5
6
7
8
9
10
83
11
12
13
14
15
16
17
18
19
20
NB/EA
NB
21
22
23
24
EA
DOWNLINK (TRANSMIT)

Fig 2: Transponder hierarchy on Optus C1 satellite, which provides DTH subscription television services to Australia. Source: C1 Satellite Payload information, April, 2001, Optus.

27. In a subscription television service the key to maximizing use of the available capacity of each satellite transponder (and thus minimising annual satellite costs) is to combine the variable bit rate streams from a group of video channels into a fixed rate data stream that can be sent up to the transponder. This combining process is usually undertaken in a statistical multiplexer (or Stat Mux) which is a device that dynamically distributes the available bandwidth among multiple (often unlike) video programs in order to maximize both the number of programs that can be supported and the overall picture quality of each video channel. Stat Muxs, as the name implies, use highly advanced mathematical algorithms to handle the constantly changing dynamics of the relatively low bit rate video signals and optimally share the fixed available output bandwidth between the incoming channels. This operation, which requires constant monitoring of the input signal's characteristics, takes place frame per frame.

28. Figure 3 indicates the technology advances over the last 10 years that have seen average data rates for Standard Definition Television (SDTV) channels drop from around 7 Mbits/s in 1994 to some 2-3 Mbits/s at this time. While a typical subscription television service operator is currently likely to achieve approximately 3 Mbits/s average data rate per channel, it is useful to note that a new entity wishing to roll out a future DTH satellite business would be able to achieve even better efficiencies by adopting recent technology advances. For example, average rates for a SDTV channel are predicted to drop to around 1 Mbits/s with the application of advanced statistical multiplexing techniques, newer compression schemes such as MPEG-4 and Windows Media 9, DVB-S2 modulation and higher transmission modes such as 8PSK and 16QAM, albeit requiring a small increase in either satellite EIRP or in DTH dish size.

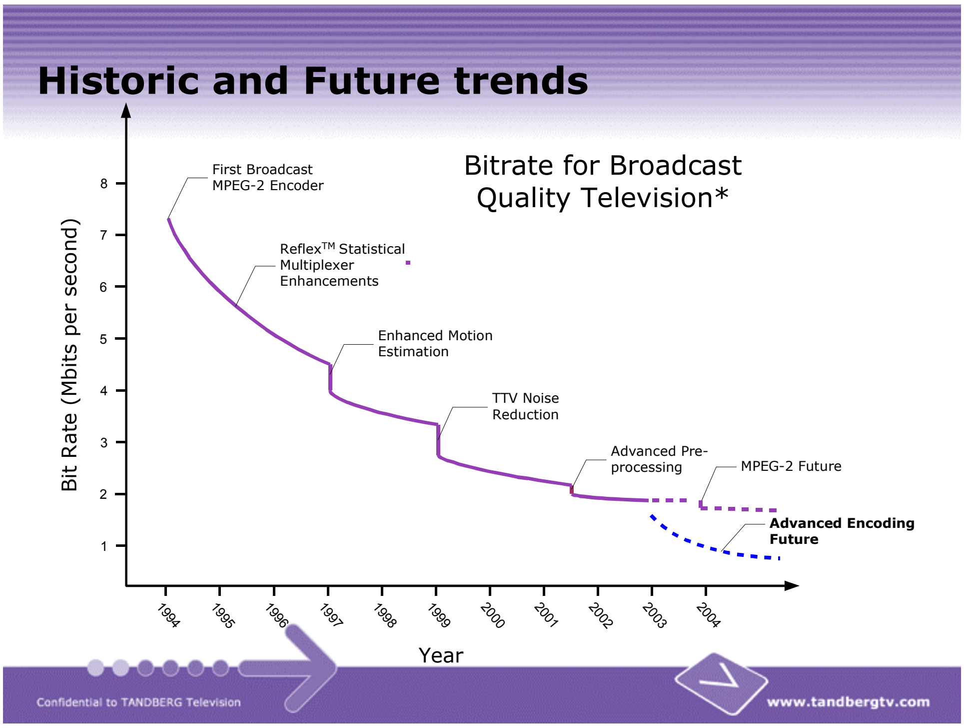

Fig 3: Reduction over last 10 years in required average bit rate to support 1 SDTV channel. Current theoretical rate of around 2 Mbits/s assumes at least 10 non coherent channels in the Stat Mux input group. Australian DTH services are presently achieving average bitrates of around 3 Mbits/s. Source: 'MPEG-2 trend', Tandberg.

iii. Satellite life

29. Clearly it is important that the satellite (and, if necessary, its replacement) will be available for the life of the DTH business. Recently launched satellites suitable for subscription television services have predicted in-service lifetimes of around 15 years and the possibility of some additional years in a useable inclined orbit after that. It is standard practice for a satellite operator to negotiate ongoing capacity on a replacement satellite at the existing location some years before the current satellite expires. A replacement satellite at a different location would necessitate a 're-point' of the customers' antennas, or an upgrade to antenna hardware (dual beam). Each would be logistically difficult and costly.

Answer to question 1.2

30. While each of the satellite systems shown in Table 2 are (or will be) potentially capable of supporting an Australian subscription television service,

some are only marginally suitable due to limited life, insufficient signal, non optimum location in the GSO, non preferred frequency bands or lack of necessary capacity. In order to determine which satellites are suitable, we need to look at the characteristics of each system.

31. **Existing satellite systems.** Table 3 indicates current satellite systems that are potentially capable of delivering a subscription television service. Only systems meeting the following criteria have been included[8]:

- Coverage: GSO position between 90E and 180E.
- Frequency band: Ku band up and down, with support for at least half (250 MHz) of the 12.25-12.75 GHz downlink band.
- End of life: non inclined orbit till at least end 2009 (earlier if replacement satellite planned).
- Downlink EIRP: at least 46 dBW in the major population areas.

[8] *Some potential systems not included in Table 3 are:*
- *Measat 2 @ 148E due to Ku band downlinks being in the 11.45-11.7 GHz band (shared with the Fixed Service), 2008 end of life and max Ku band capacity to Australia of 4 transponders.*
- *Various Intelsat (eg 600/700 series) due to lack of coverage, non optimum Ku band downlink segment or limited life.*
- *New Skies NSS-5 @ 183E as outside 90E to 180E range (low elevation angle Australian west coast, eg 11^o in Perth).*

Operator	Satellite	Orbit loc	EIRP[a]	Launch/ End life	Ku FSS txpndrs[c]	Txpndrs to AUS[d]	Planned replacement
Optus	**B1**	**160E**	**46[b]**	**1992/2007**	**15**	**8**	***D1 in 2006***
	B3	**156E/152E**	**46[b]**	**1994/2009**	**15**	**8**	
	C1	**156E**	**51**	**2003/2018**	**24**	**20**	***D2 in 2007[e]***
PanAmSat	**PAS-2**	**169E**	**46**	**1994/2009**	**16**	**7**	***PAS-30 @ 170E in 2007***
	PAS-8	**166E**	**51**	**1998/2013**	**24**	**9**	
Asiasat	**Asiasat-3S**	**105.5E**	**46+**	**1999/2014**	**16**	**4**	
	Asiasat-4	**122.2E**	**51**	**2003/2018**	**16**	**8**	
New Skies	**NSS-6**	**95E**	**50+**	**2002/2016**	**60**	**18**	

Table 3: Existing satellite systems having the characteristics referred to in question 1.1

[a] *EIRP (dBW) to main population centres.*
[b] *B1 & B3 also have 51 dBW 'HP' (high performance) beams to SE Australia and Perth.*
[c] *Number of Ku transponders physically on satellite. Not all available for Australian DTH.*
[d] *Typical max during the last few years.*
[e] *D2 to supplement C1with 24 BSS transponders. Each satellite is to operate from 156E.*

32. **Planned satellite systems.** In addition to these existing systems there are new satellites planned for Australia that are expected to come on line in the short term. These are:

- Optus D1 (FSS) which will replace Optus B1 at 160E in 2006.
- Optus D2 (BSS) which will complement Optus C1 at 156E in 2007.
- PanAmSat PAS-30 (FSS) at 170E which will replace PAS-2 at 169E around 2007 (this satellite has been filed with the ITU, but is not yet confirmed).
- FOXTEL's licensed BSS system at 152E.

The current and potential new systems are included in Table 4 below:

[CONFIDENTIAL]

2. Capacity

2.1 How much capacity on these satellites is available now which is suitable to provide subscription television services? How much suitable capacity will be available in the future?

2.2 How many subscription television channels can be provided using a typical satellite transponder?

2.3 What is the typical cost of licensing satellite transponder capacity?

Answer to question 2.1

33. While each of the satellites/replacement satellites in Table 4 is technically capable of delivering a DTH service to Australian customers, the ability to provide service is often limited by the availability of transponders. Table 4 indicates the number of physical Ku band transponders carried on each satellite and also the maximum number that are usually switched onto Australian downlink beams (the rest typically supplying service to Asia or NZ). Importantly, the number of available transponders deployed on Australian beams is a decision for the satellite operator, taking into account the requirement in Australia and in the regions that can be served from the particular orbit location. Therefore, there is always a possibility that the number of transponders providing service to Australia could change.

34. Table 5 includes information on transponder availability and pricing (as at Aug, '05) for the existing satellites shown in Table 4. The information was supplied by Optus, PanAmSat, Asiasat and New Skies Satellites. Contact details appear in Appendix D.

[CONFIDENTIAL]

35.

36. As an alternative to acquiring capacity directly from one of the satellite vendors in Table 5 it would be possible to purchase capacity from a satellite reseller such as GlobeCast Australia. GlobeCast currently delivers DTH services on Optus B3 and C1 and on PanAmSat PAS-8. Resellers typically provide capacity on a 'per channel' basis (rather than per transponder) and are particularly attractive to DTH providers having a limited number of programs to deliver.

37. **[CONFIDENTIAL]**

Answer to question 2.2

38. As indicated above, a typical 36 MHz Ku band transponder is capable of supporting a transmission stream approaching 30 Msymbols/s which, with 3/4 FEC and QPSK modulation, translates to an input data rate of nearly 40 Mbits/s. In my experience, system overheads will typically amount to some 6 Mbits/s (comprising audio channels: 3 Mbits/s, system information, control and other non video material: 2 Mbits/s and headroom provision: 1 Mbit/s), hence there will be around 33 Mbits/s left for the group of video channels that will be applied to the transponder uplink.

39. The task of the Stat Mux in this configuration is to combine a maximum number of video channels into the fixed 33 Mbits/s output stream, while ensuring that the quality of each channel meets a chosen minimum standard (for example a particular channel might always have access to 4 Mbits/s). A skilled operator will try to apply to the Stat Mux a carefully chosen mix of program material which includes sport, movies, entertainment, news etc such that a reasonable balance is obtained between the high and low data rate sources. If there are too many high dynamics programs in the mix the Stat Mux will become congested and digital 'blocking' will be seen by viewers; if there are too many low dynamics programs valuable capacity will be wasted.

Table 7 indicates typical peak and average data rates needed to support the main program types used in DTH delivered subscription television services.

40. **[CONFIDENTIAL]**

Answer to question 2.3

41. **[CONFIDENTIAL]**

3. New satellites

3.1 Can an entity launch a new satellite now or in the future capable of being used to provide subscription television services to Australian customers? If so:

(a) what will it have to do in order to do so and how much will this cost; and

(b) how much time will have to elapse between the decision to launch a satellite and the provision of subscription television services?

Answer to question 3.1(a)

42. In order to launch a new satellite of sufficient capacity to deliver a subscription television service to Australian customers a number of major undertakings would be necessary. The main undertakings relating directly to satellite delivery would be:

- Choice of subscription television **technology.**
- Securing suitable Ku band uplink/downlink **spectrum** from the ACMA.
- Procurement and launch of a suitable **satellite**; and
- Establishment of appropriate **ground station infrastructure.**

43. **Technology choice:** One of the major decisions for the entity to take would be which technology to use to deliver the DTH service. If the decision was being made a year or two back it would have been relatively straightforward: DVB-S system, MPEG-2 compression and QPSK transmission would have been obvious choices. Each of these technologies was proven, of known performance and was being used by existing satellite delivered DTH services in Australia.

44. However, if the technology decision was being made today, or in the short term, the entity would need to look at DVB-S2, MPEG-4 (or similar advanced video coding standard) and 8PSK, 16QAM (or higher) transmission mode. These more recent technology developments would lend themselves to significantly improved (possibly 70% plus) transmission efficiency, allowing perhaps 20 or so SDTV channels to be supported by a 36 MHz satellite transponder. They would also allow the entity to consider providing HDTV

and other advanced formats to differentiate his business, although lack of set top box (STB) compatibility with other providers might be a downside.

45. **Spectrum:** At the satellite spectrum auction in November, 2001 the ACMA sold the 152E allocation to FOXTEL for a once off price of $1M. An apparatus licence (with an annual fee of some $80k) was issued to FOXTEL for a five year period, expiring in May, 2007. The 164E allocation did not sell and is still available today. Although not included in the auction, the ACMA advised that suitable uplink spectrum in the 17 GHz band was available for licensing of gateway stations to either satellite.

46. Consistent with the BSS Plan, the 2 licences on offer each authorised the operation of 21 downlink channels (each of 27 MHz bandwidth in the 11.7-12.2 GHz band), 3 with national coverage and 18 over specific geographic areas. However, the ACMA also advised that it had initiated international filing changes which, subject to coordination, would support the operation of 24 Australia wide BSS channels from each location.

47. In the post auction period the ACMA has made it clear on a number of occasions that, if there was sufficient interest, a licence to use the 164E slot would be allocated. The latest pronouncement on this issue was in the ACMA's recent Spectrum Management Strategy document *From DC to Daylight-Accounting for Use of the Spectrum in Australia, A Spectrum Management Strategy, June 2004,* in which it was stated: "A licence to access the allocation at 152°E has been issued. If demand emerges, the ACMA would be prepared to allocate the available apparatus licences to access the allocations at 164°E and 144.1°E".

48. The latter allocation at 144.1E would also be of interest to the entity. This slot is Australia's formal position in the planned FSS service, known in the ITU Radio Regulations as the "Appendix 30B plan". Ku bands 10.7-10.95 and 11.20-11.45 GHz (downlinks) and 12.75-13.25 GHz (uplinks) are available for this service. Importantly, the ACMA has also filed with the ITU the

unplanned FSS bands and so, subject to coordination, it would be possible to operate from the 144.1E location using the 12.25-12.75 GHz (downlinks) and 14-14.5 GHz (uplinks) spectrum.

49. Annual apparatus licence fees for one of these slots would amount to around $400k (assuming 24 Ku band downlink channels occupying 500 MHz Australia wide and equivalent uplink bandwidth from a couple of earth stations located in major capital cities)

50. In summary, an entity proposing to offer a satellite delivered subscription television service to Australian customers could negotiate with the ACMA to purchase either of the remaining slots. It could be expected that if the entity indicated such interest the ACMA would 'test the market' by seeking other expressions of interest. Depending on the outcome of that process it is likely that the ACMA would either carry out another auction or negotiate directly with the entity. Whatever the allocation mechanism, it could be expected that the entity would have an excellent chance of securing one of the orbital locations on offer and could proceed to build, launch and operate a DTH satellite to provide a subscription television service to Australian customers.

51. As with the 152E slot the ACMA would likely place a 5 year deadline on the time to bring the service to market. Also, the previous $1M purchase fee would probably be a good guide to the likely sale price and ongoing annual apparatus licence fees of some $400k would apply (to cover 24 Ku band downlink channels Australia wide plus equivalent up links from a couple of major capital cities) .

52. **[CONFIDENTIAL]**

53. **[CONFIDENTIAL]**

Answer to question 3.1(b)

54. **[CONFIDENTIAL]**

55. **[CONFIDENTIAL]**

4. Satellite modifications

Assume that a FOXTEL subscriber:

- receives the FOXTEL service from the Optus C1 satellite at orbital slot 156ºE;
- has the following satellite reception equipment: a dish between 65cm and 85cm with one low noise block downconvertor only; and
- wishes to also receive an additional subscription television service from one of the satellites referred to in Question 1.2 (other than the Optus C1 satellite).

For each of the satellites referred to in Question 1.2:

4.1 What modifications would have to occur to the subscriber's satellite reception equipment in order for the subscriber to receive a subscription television service from that satellite as well as continuing to receive the FOXTEL service from the Optus C1 satellite?

4.2 How much would these various modifications cost (excluding labour)?

Answer to question 4.1

56. A customer receiving the FOXTEL service from the Optus C1 satellite at 156E who wishes to also receive a DTH subscription television service from another satellite will probably have to upgrade his satellite reception equipment. The upgraded installation will need to allow for the simultaneous (or near simultaneous) reception of two satellite signals compared to the current requirement to receive only the FOXTEL signal.

57. The degree to which the subscriber's reception equipment will need to be upgraded will depend to a large part on whether the second satellite is at the same orbital location as Optus C1, i.e. 156E, or at a different location. In the

former case (referred to as **Category 1** below) the upgrade will be significantly less complex as the two DTH signals emanating from 156E will be able to be received on a single dish/single low noise block down converter/feed horn (LNBF), hereafter referred to as an 'LNB'. In the latter case (referred to as **Category 2** below) the installation will need to receive the second signal from a satellite that could be separated from Optus C1 by say 20 degrees or more on the GSO arc (61 degrees in the case of NSS-6). The degree of separation will determine the type of installation required by the subscriber.

58. Whatever the satellite arrangements, the subscriber's dish/LNB will need to feed the received signal(s) to a STB for processing. Either a single STB, fed from a single LNB (or from twin LNBs) or dual STBs fed from either a dual output LNB, or from twin LNBs, would be suitable. While various LNB/STB configurations are possible, it is understood that arrangements between FOXTEL and the provider of the additional subscription television service will result in the customer's existing FOXTEL STB being able to access the additional program channels from the second provider and that the FOXTEL conditional access (CA) system will be used. It is therefore assumed in this report that, while it would be possible to use two STBs for this application, a single STB will be used by the subscriber to receive the two subscription services from the two satellites.

59. **Category 1: Co-located satellites at 156E.** In this case the installation will need to be able to receive both the 12.25-12.75 GHz band FSS signal from the Optus C1 satellite and the 11.7-12.2 GHz band BSS signal from the planned Optus D2 satellite (see Table 2 above for details). That is, the overall bandwidth of the signals to be received will effectively double, from 500 MHz to 1050 MHz. While the dish and the LNB will each play their part in receiving the wider bandwidth, the specification of the LNB will be the critical factor in ensuring that the FSS and BSS signals are satisfactorily received. The upgraded installation will comprise:

- **Satellite dish:** The existing 65 cm to 85 cm diameter satellite dish can be expected to perform quite satisfactorily over the wider 1050 MHz bandwidth. Even though Australian subscription television services have to date utilised the narrower 12.25-12.75 GHz frequency band, all Ku band dishes of this size manufactured over recent years have been designed to perform well over the wider frequency range.[10] Hence, the customer will very likely be able to retain his satellite dish.

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Most of the currently installed wideband LNBs have only a single output connection, although some have twin outputs to feed STBs with built-in recorders. Given that subscribers will be able to use a single STB to receive the two subscription services, only a single output LNB will be needed for this application (with a twin output continuing to be needed to support STBs with built-in recorders).

It will be necessary to connect the output of the wideband LNB to the STB via a single coaxial cable. The STB will be able to select the desired vertical or horizontal signal polarisations used on the Optus C1 and planned D2 satellites via standard 13/18 volt 'dc switching'.[11]

[11] *'DC switching' is a technique used to force the LNB to change its polarisation. If 13 volts dc (approx.) is applied to the LNB it will output channels to the STB which are vertically polarised. If 18 volts dc (approx.) is applied, horizontally polarised channels will be selected. The STB, which has a stored list of the polarisation of each channel, generates the desired 13 or 18 volts each time the subscriber changes channels and applies it to the coaxial cable connecting it to the LNB.*

60. **Category 2: Optus C1 at 156E plus a second satellite at a different orbital location.** In this case the installation will need to be upgraded to receive both the Optus C1 FSS signal in the 12.25-12.75 GHz band and an FSS signal in

the same band (or possibly a BSS signal in the 11.7-12.2 GHz band) from another satellite (see Table 2 above for details). Various reception equipment configurations are capable of achieving this, viz:

A. Single dish with one 'integrated dual feed horn' LNB

B. Single dish with two LNBs

C. Two dishes, each with one LNB; and

D. Single steerable dish/LNB (not recommended)

Each of the proposed configurations requires an upgrade to the customer equipment installation currently used to receive the FOXTEL service on Optus C1. Furthermore, there are significant performance capability differences between the various configurations.

61. **Option A: Single dish with one 'integrated dual feed horn' LNB.** This option would allow the customer to retain his existing dish but would require a replacement LNB to be used. A new '2 in 1' LNB would be specially designed to support the simultaneous reception of two satellites separated by up to 4 degrees from Optus C1, i.e. the second satellite would have to be at either 152E or 160E[12] While the need for a wideband or narrowband LNB would be dictated by the frequency bands used by the particular satellites it could be expected that only wideband units would be used to effectively 'future proof' the installation.

[12] *Technical design limitations mean that this particular type of composite LNB would not be suitable for satellite spacings greater than +/- 4 degrees from C1.*

62. **[CONFIDENTIAL]**

[CONFIDENTIAL]

63.

64. Like the Category 1 configuration, the output of the integrated LNB would be connected via a single coaxial cable to the input of the STB. Selection of the desired satellite would be via a 22 kHz tone signal[13] generated by the STB. Again, standard 13/18 volt dc switching would be used to change the LNB's polarisation.

[13] *'Tone switching' is another standard technique used to send commands from the STB to the LNB, via the interconnecting coaxial cable. In this case, a 22 kHz ac voltage is used to force the LNB to change its frequency band, eg from the 11.7-12.2 GHz band to the 12.25-12.75 GHz band. As with 'dc switching' the LNB has a stored list of each channel's frequency band. Each time the subscriber changes channels the STB transmits to the LNB a dc switching voltage (to control the polarisation) together with a 22 kHz ac signal (or the absence of such a signal) to select the desired frequency band.*

65. **[CONFIDENTIAL]**

66. **[CONFIDENTIAL]**

[14] *'Skew' describes the angle by which the satellite's signals have been rotated. For example, in a linearly polarised system, the satellite will transmit in both the vertical and horizontal planes (to effectively double the capacity of the satellite). The planes are at 90 degrees to each other. Although not usually implemented, further rotation of these planes can be added for technical performance reasons. Since the first Optus (nee Aussat) A series satellites in 1985, all Optus systems have employed an additional skew angle of 45 degrees. In Table 4, only Optus systems (including the planned D1 and D2 satellites) employ this additional skew.*

67. **[CONFIDENTIAL]**

68. **[CONFIDENTIAL]**

69. **[CONFIDENTIAL]**

70. **[CONFIDENTIAL]**

[CONFIDENTIAL]

71. **Option C: Two dishes, each with one LNB.** The third option for updating the subscriber installation to receive both the existing C1 satellite and another satellite providing a subscription television service would be to add a second dish/LNB to the existing installation. The advantage of this approach is that it would work well over a far wider range of satellite separations; essentially, all candidate systems included in Table 4 could be received, even NSS-6 at 95E.

72. The size of the second dish would ideally be chosen to complement the existing 65 cm or 85 cm antenna (and to meet local Council requirements which often limit domestic dishes to 90 cm). It would also need to accommodate the second satellite's signal and orbital characteristics at the customer's location. The second LNB would cover the particular FSS or BSS frequency band (a wideband unit would cover both bands). Again, combining the two LNBs into the subscriber's STB would be done with a 22 kHz tone

switch controlled by the STB with LNB polarisation being selected by standard 13/18 volt dc switching. Fig 6 shows this configuration.

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73. **Option D: Single steerable dish/LNB.** For completeness, a fourth option of using a single steerable dish/single LNB has been included. This option would see the customer's existing installation upgraded with the addition of a motor driven, steerable dish assembly. The advantage of this configuration is that it could potentially receive all the candidate systems in Table 4 with a single dish. However, there are some **significant limitations** including:

- **Cost:** the installation would cost some hundreds of dollars.
- **Complexity:** the STB would have to be upgraded to control the dish.
- **Performance:** the unit would be comparatively slow to lock onto a new satellite (or return to a previous satellite) after a channel was chosen on the STB.

- **Compatibility:** Some core features of DTH television systems (eg electronic program guide, EPG) rely on regular access to a satellite's 'home transponder'. If that access was removed for a time, as would happen if the dish was pointed at another satellite, these features would not be immediately available when required. This would not be acceptable to customers.
- **Skew angle:** a standard motor drive unit would not be able to accommodate different satellite skew angles (eg Optus uses 45 degrees, most other satellites use zero degrees).

Option D is considered to have too many negative aspects to recommend it for this application. The inability to ensure continuous EPG access would effectively disqualify it from further consideration.

74. In summary, there are a number of technical solutions available to an existing FOXTEL customer wishing to receive an additional subscription television service from a second satellite. Essentially, the type of receiving equipment modifications would be dictated by the orbital separation between the two satellites. While the installation of a second dish/LNB would offer maximum flexibility in satellite choice and would maintain the level of performance/availability that the customer currently received, single dish solutions could be adopted for satellite spacings out to about 10 degrees separation. However, as indicated, the (second) service provider would need to carefully assess the level of performance that would be available on the new service at the particular location and might need to recommend an upgrade to a larger dish to maintain availability during wet weather.

Answer to question 4.2

75. The cost of modifications to receive an additional subscription television service from a second satellite will depend on a number of factors, including:

- Which equipment configuration is required (which will be broadly dependent on the orbital location of the second satellite).

- The subscribers current equipment (dish size, LNB bandwidth); and
- Site suitability for particular configurations, eg the customer's site may not lend itself to two dishes.

76. This section provides typical hardware prices for the various options detailed in the answer to question 4.1. In all cases the prices are those that might be obtained for high volume bulk orders, rather than for individual ('one-off') purchases. Consistent with that requested in question 4.2, labour prices to carry out the upgrades have not been included. Except for the specific Category 1 case, where the customer has a wideband LNB installed, all other configurations will require modifications to the existing installation. Table 8 summarises the approximate costs:

[CONFIDENTIAL]

Bill McDonald

30 September, 2005

Appendix A – Curriculum Vitae of Bill McDonald

Australian Spectrum Consultants Pty Ltd is a boutique consultancy founded by Mr McDonald in 1997 to provide specialist engineering advice to large start-up telecommunications and broadcasting ventures. During the last 8 years the company has undertaken numerous assignments for major satellite operators and potential satellite operators in the United States, Europe and Australia.
Prior to establishing ASC, Mr McDonald had peak executive roles at Vodafone Australia Pty Ltd (National Technical Manager, 1993-1997) and at Hutchison Telecommunications Pty Ltd (National Technical Manager, 1989-1993) leading large professional network rollout teams in both companies.
Before 1989 Mr McDonald had senior engineering and management roles in the Federal Department of Communications in Canberra, specialising in radio spectrum policy to accommodate new technologies.

Mr McDonald graduated Bachelor of Engineering with a communications major from the University of Technology, Sydney in 1981 and has practiced as an engineer since then in the government and private sectors. His Australian commercial experience has included leadership of major 'start-up' satellite businesses for Hutchison (satellite paging) and Vodafone (Globalstar's mobile satellite).
Since establishing ASC, Mr McDonald has successfully taken on major assignments for international start-up business ventures. The satellite assignments have included:

- Alcatel France (1997-2000): significant engineering work in International Telecommunications Union Radiocommunication (ITU-R) study groups on satellite issues for the planned SkyBridge satellite system.
- European Commission (1999 ongoing): ITU-R engineering studies relating to the planned Galileo satellite system.
- Globalstar (1998 ongoing): ITU-R engineering studies relating to the Globalstar mobile satellite system in Australia and worldwide.
- FOXTEL (2001 ongoing): review of future satellite options, specifically Intelsat 604 @ 157E, for possible Pay Television delivery to Australia, plus engineering work related to uplinking of digital programs to existing Optus C1 satellite. Also, since 2003, management of FOXTEL's BSS satellite licence in Australia and internationally.
- Orange France (2004 ongoing): sharing studies of future 4G mobile phones with various satellite systems.
- FOXTEL (June 2005): preparation of an Independent Expert Report, addressing satellite delivered subscription television services, for submission to the Federal Court of Australia.

Mr McDonald has represented Australia at five World Radiocommunication Conferences (WRCs) between 1992 and 2003 and is on the Australian delegation to the coming WRC-07 Conference. In addition he has represented Australia at over 25 international ITU-R technical meetings dealing mainly with satellite engineering issues.

Appendix B – Guidelines for Expert Witnesses in proceedings in the Federal Court of Australia

Practice Direction

This Practice Direction replaces the Practice Direction on Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia issued on 4 September 2003.
Practitioners should give a copy of the following guidelines to any witness they propose to retain for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based on the specialised knowledge of the witness (see *Part 3.3 - Opinion* of the Evidence Act 1995 (Cth)).
M.E.J. BLACK
Chief Justice
19 March 2004

Explanatory Memorandum

The guidelines are not intended to address all aspects of an expert witness's duties, but are intended to facilitate the admission of opinion evidence[1], and to assist experts to understand in general terms what the Court expects of an expert witness giving opinion evidence. Additionally, it is hoped that the guidelines will assist individual expert witnesses to avoid the criticism that is sometimes made (whether rightly or wrongly) that expert witnesses lack objectivity, or have coloured their evidence in favour of the party calling them.
Ways by which an expert witness giving opinion evidence may avoid criticism of partiality include ensuring that the report, or other statement of evidence:

(a) is clearly expressed and not argumentative in tone;
(b) is centrally concerned to express an opinion, upon a clearly defined question or questions, based on the expert's specialised knowledge;
(c) identifies with precision the factual premises upon which the opinion is based;
(d) explains the process of reasoning by which the expert reached the opinion expressed in the report;
(e) is confined to the area or areas of the expert's specialised knowledge; and
(f) identifies any pre-existing relationship between the author of the report, or his or her firm, company etc, and a party to the litigation (eg a treating medical practitioner, or a firm's accountant).

An expert is not disqualified from giving evidence by reason only of the fact of a pre-existing relationship with the party that proffers the expert as a witness, but the nature of the pre-existing relationship should be disclosed. Where an expert has such a relationship with the party the expert may need to pay particular attention to the identification of the factual premises upon which the expert's opinion is based. The expert should make it clear whether, and to what extent, the opinion is based on the personal knowledge of the expert (the factual basis for which might be required to be established by admissible evidence of the expert or another witness) derived from the ongoing relationship rather than on factual premises or assumptions provided to the expert by way of instructions.
All experts need to be aware that if they participate to a significant degree in the process of formulating and preparing the case of a party, they may find it difficult to maintain objectivity.
An expert witness does not compromise objectivity by defending, forcefully if necessary, an opinion based on the expert's specialised knowledge which is genuinely held but may do so if the expert is, for example, unwilling to give consideration to alternative factual premises or is unwilling, where appropriate, to acknowledge recognised differences of opinion or approach between experts in the relevant discipline.
The guidelines are, as their title indicates, no more than guidelines. Attempts to apply them literally in every case may prove unhelpful. In some areas of specialised knowledge and in some circumstances (eg some aspects of economic "evidence" in competition law cases), their literal interpretation may prove unworkable. The Court expects legal practitioners and experts to work together to ensure that the

[1] As to the distinction between expert opinion evidence and expert assistance see *Evans Deakin Pty Ltd v Sebel Furniture Ltd* [2003] FCA 171 per Allsop J at [676].

guidelines are implemented in a practically sensible way which ensures that they achieve their intended purpose.

Guidelines

1. General Duty to the Court[2]

1.1 An expert witness has an overriding duty to assist the Court on matters relevant to the expert's area of expertise.

1.2 An expert witness is not an advocate for a party.

1.3 An expert witness's paramount duty is to the Court and not to the person retaining the expert.

2. The Form of the Expert Evidence[3]

2.1 An expert's written report must give details of the expert's qualifications, and of the literature or other material used in making the report.

2.2 All assumptions of fact made by the expert should be clearly and fully stated.

2.3 The report should identify who carried out any tests or experiments upon which the expert relied in compiling the report, and state the qualifications of the person who carried out any such test or experiment.

2.4 Where several opinions are provided in the report, the expert should summarise them.

2.5 The expert should give reasons for each opinion.

2.6 At the end of the report the expert should declare that "[the expert] has made all the inquiries which [the expert] believes are desirable and appropriate and that no matters of significance which [the expert] regards as relevant have, to [the expert's] knowledge, been withheld from the Court."

2.7 There should be included in or attached to the report (i) a statement of the questions or issues that the expert was asked to address; (ii) the factual premises upon which the report proceeds; and (iii) the documents and other materials which the expert has been instructed to consider.

2.8 If, after exchange of reports or at any other stage, an expert witness changes a material opinion, having read another expert's report or for any other reason, the change should be communicated in a timely manner (through legal representatives) to each party to whom the expert witness's report has been provided and, when appropriate, to the Court.[4]

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[2] See rule 35.3 Civil Procedure Rules (UK); see also Lord Woolf "Medics, Lawyers and the Courts" [1997] 16 CJQ 302 at 313.

[3] See rule 35.10 Civil Procedure Rules (UK) and Practice Direction 35 - Experts and Assessors (UK); *HG v the Queen* (1999) 197 CLR 414 per Gleeson CJ at [39]-[43]; *Ocean Marine Mutual Insurance Association (Europe) OV v Jetopay Pty Ltd* [2000] FCA 1463 (FC) at [17]-[23].

[4] The "Ikarian Reefer" [1993] 20 FSR 563 at 565.

2.9 If an expert's opinion is not fully researched because the expert considers that insufficient data are available, or for any other reason, this must be stated with an indication that the opinion is no more than a provisional one. Where an expert witness who has prepared a report believes that it may be incomplete or inaccurate without some qualification, that qualification must be stated in the report.[4]

2.10 The expert should make it clear when a particular question or issue falls outside the relevant field of expertise.

2.11 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the opposite party at the same time as the exchange of reports.[5]

3. Experts' Conference

3.1 If experts retained by the parties meet at the direction of the Court, it would be improper conduct for an expert to be given or to accept instructions not to reach agreement. If, at a meeting directed by the Court, the experts cannot reach agreement about matters of expert opinion, they should specify their reasons for being unable to do so.

[5] The "Ikarian Reefer" [1993] 20 FSR 563 at 565-566. See also Ormrod "Scientific Evidence in Court" [1968] Crim LR 240.

Appendix C – Reference documents used by Bill McDonald

Author	**Main date**	**Description**
Australian Communications and Media Authority, ACMA	Jan, 2005	Australian Radiofrequency Spectrum Plan
ACMA	Oct, 2001	Space Licence Allocation Information Memorandum
ACMA	Jun, 2004	From DC to Daylight – Accounting for Use of the Spectrum in Australia
AsiaSat	Aug 2005	Correspondence from Asiasat
AsiaSat	Various	AsiaSat 3S and 4 coverage maps, engineering data
Böröczky, Ngai and Westermann	Jul, 1999	Statistical multiplexing using MPEG-2 video encoders
Broadcast Engineering	June, 2002	MPEG encoders and multiplexers
FOXTEL	Jun, '98 to Aug, '05	Various documents dealing with the provision of satellite services, satellite capacity, transponder pricing and engineering matters.
Intelsat	Aug; '05	Various references dealing with satellite capacity to Australia.
International Telecommunications Union	2004 edition	Radio Regulations, Table of Frequency Allocations, WRC Final Acts.
International Telecommunications Union	Various	ITU-R recommendations relating to band sharing with the fixed service (FS) and on satellite performance. Mainly from Study Group 4
Lyngsat	Various	Satellite data from lyngsat website
Measat	Various	Measat 2 technical user guide.
Morello and Mignone	Oct; 2004	DVB-S2 'Ready for lift off'
Morgan	Oct; 1999	'Why is Bigger Better?'
Muriel	June, 2000	What is Digital Satellite Television?
New Skies Satellite	Aug, 2005	Correspondence from NSS on NSS-5 and NSS-6 satellites
New Skies Satellite	Various	Engineering data on NSS satellites
Optus	Aug; 2005	Correspondence from Optus on satellite capacity
Optus	Apr; 2001	C1 payload information
Optus	May; 2002	'B' series Satellite Network Designers Guide
Optus	Apr; 2002	Optus C1 Satellite guide
PanAmSat	Aug; 2005	Correspondence from PanAmSat on PAS-2 and PAS-8 satellites
Scientific Atlanta	Feb; 2005	MPEG-2 Eencoders
Scopus Network Technologies	Sept; 2003	'Advanced Encoding and Statistical Multiplexing'
Sion	Nov; 2004	Co-ordination of Satellite Networks
Tandberg	Dec; 2004	Reflex statistical multiplexing technical note
Tandberg	Oct; 2003	'MPEG-2 trend'

Appendix D – Contact details of organisations consulted by Bill McDonald in the preparation of this report

Organisation	Address	Main contact
Hills Industries Ltd	10-12 Wiggs Road, Riverwood AUS	Allen Oliver, Group General Manager
Jonsa Ellies (Aust) Pty Ltd	107 Carnarvon St ; Silverwater AUS	Rex Lee, Director
Asia Satellite Telecommunications Co. Ltd	33 Hysan Ave; Causeway Bay, Hong Kong.	Sabrina Cubbon, General Manager, Marketing
Foxtel Management Pty Ltd	5 Thomas Holt Dr; Nth Ryde AUS	Peter Smart, Director of Engineering
GlobeCast Australia Pty Ltd	86 Dickson Ave; Artarmon AUS	Mark Lobwein, DTH Manager
New Skies Satellite	The Hague, The Netherlands	Anthony Baker, Vice President
PanAmSat Asia Pty Ltd	2 Chifley Sq; Sydney AUS	David Ball, Vice President
SingTel Optus Pty Ltd	101 Miller St; North Sydney AUS	Paul Sheridan, General Manager