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Expert report – Issues arising from Optus' submissions on Telstra's proposed HFC exemption

Prepared for Gilbert + Tobin

PUBLIC VERSION

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1 Preliminary matters

Instructions

1.1 In relation to the SingTel Optus submissions to the Australian Competition and Consumer Commission regarding Telstra's December 2007 Exemption Application for Fixed Line Services in the Optus HFC Area (**Optus Submissions**) and the exemption application itself, I have been asked to express my professional opinion on the following questions:

1. How has the technology used by cable companies to deliver telephony services evolved and what are the implications for each type of technology in respect of delivery of services to MDU? In answering this question, please have specific regard to the technology deployed by Optus and comment on current technology being deployed in North America.

2. What is the range of number of units per MDU in North America and is there a type of MDU based on units per MDU which would be considered "unserviceable" in North America? Additionally, can you comment on Optus' submissions relating to the cost of connecting MDUs? In answering these questions, please consider and comment on the response that Optus made in respect of MDU connections in the Optus Submissions, including its confidential material accessed under terms of confidentiality.

3. To what extent is the availability and reliability of HFC networks different from telephony access networks and does aerial cabling change the response to this question? In answering this question, please consider and comment on the response that Optus made in respect of its HFC availability in the Optus Submissions, including its confidential material accessed under terms of confidentiality.

4. What are the return bandwidth limitations in HFC networks and how are these dealt with in North America?

5. The Optus Submissions include comments on node splitting. Why would an HFC network engineer engage in node splitting? What are the technical issues involved and what are the associated costs?

6. What is the state of deployment of DOCSIS 3.0 technology in the US and could Optus deploy this technology?

Author of Report

1.2 This report has been prepared by Michael G. Harris who is the principal of Harris Communications Consulting LLC.

1.3 I have significant practical experience in the cable television industry in the United States including being the Vice President of Engineering and the Chief Technical Officer for Century Communications (from 1973 to 1999). I also have significant experience in the telecommunications industry having worked as the Vice President of Engineering and the Chief Technical Officer for Citizens Communications from 1999 to 2004. Citizens is the incumbent wireline provider in a number of regions in the US. During the period 1989 to 1997 I was also the Senior Vice President of Engineering at Centennial Cellular, a wireless cellular operator.

1.4 My experience means that I have been in charge of engineering for each of the 3 technologies:

(a) cable;

(b) wireline telecommunications; and

(c) wireless telecommunications.

1.5 Since 2005, I have provided consulting services through my own business to a number of leading providers of cable services and vendors to the cable industry.

1.6 A copy of my resume is attached as Attachment A.

Federal Court Rules

1.7 Set out at Attachment B is a copy of Version 6 of the "Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia" (**Guidelines**). A copy of Version 5 was provided to me before I commenced drafting this report. A copy of Version 6 was provided to me after it was published in May 2008, and I have reviewed it before submitting this report.

1.8 I have drafted this report to comply with those Guidelines. Apart from the work in preparing my First Report for Peter Waters and Associates, I have no pre-existing relationship with Gilbert + Tobin and I have never been retained by or employed by Telstra.

Currency used in this report

1.9 All references to monetary amounts in this report are expressed in United States Dollars.

Documents and materials provided

1.10 Public Version of Telstra's Response to ACCC Discussion Paper on Telstra's Exemption Application Relating to SingTel Optus' HFC Network Submitted on 25 March 2008

1.11 Optus Submission to Australian Competition and Consumer Commission on Telstra's December 2007 Exemption Application for Fixed Line Services in the Optus HFC Area – Confidential version (**March 2008 submission**)

1.12 Optus Supplementary Submission to Australian Competition and Consumer Commission on Telstra's December 2007 Exemption Application for Fixed Line Services in the Optus HFC Area – Confidential version (**May 2008 submission**)

Additional materials relied upon for this report

1.15 I have reviewed a number of documents produced by vendors to the cable industry in the United States as well as standards issued by bodies including *the Society of Cable Telecommunications Engineers and* Cable Labs. I have also relied on the extensive body of literature regarding the cable industry that would be normally used by a practitioner in that industry. In doing this, I have relied upon documentation produced by the Society of Cable Telecommunications Engineers of which I am a member. The specific documents to which I make reference in this report are set out below:

(a) My report submitted by Telstra to the ACCC entitled "Use of HFC to deliver broadband services" and dated 12 December 2007 (**First Report**);

(b) Optus Submissions; and

(c) The Telstra submission in support of its exemption application.

Factual premises

The factual premises on which I have based my report are the facts:

- contained in the documents and materials provided to me;
- referred to in the body of this report; and
- contained in additional materials as referenced in the body of this report.

Other

In preparing this report, I have made all the inquiries that I believe are desirable and appropriate, and no matters of significance that I regard as relevant have, to my knowledge, been withheld.

2 Executive Summary

1. **How has the technology used by cable companies to deliver telephony services evolved and what are the implications for each type of technology in respect of delivery of services to MDU? In answering this question, please have specific regard to the technology deployed by Optus and comment on current technology being deployed in North America.**

   In North America, the technology used to deliver telephony over cable has evolved, or is rapidly evolving**,** from, circuit switched to packet switched based. My review of the operations of the leading MSO is that those corporations have either completed the migration from circuit switched telephony to packet switched telephony or are in the final processes of doing so. This contrasts with the Optus cable telephony system which is still circuit switched based. That Optus has allowed its network to fall so far behind normal industry practice was a surprise to me.

2. **What is the range of number of units per MDU in North America and is there a type of MDU based on units per MDU which would be considered "unserviceable" in North America? Additionally, can you comment on Optus' submissions relating to the cost of connecting MDUs? In answering these questions, please consider and comment on the response that Optus made in respect of MDU dimensions in the Optus submissions.**

   In general, there are no MDU premises which are considered "unserviceable" as a class. There are some unserviceable MDU premises but whether they are serviceable or not is determined by inspection. The range of numbers of premises per MDU is greater in the US than Australia but there are a significant number of MDU with 16 or fewer premises. I believe the costs suggested by Optus are **CiC begins CiC ends**, and I explain why in more detail in Confidential Attachment C.

3. **To what extent is the availability and reliability of HFC networks different from telephony access networks and does aerial cabling change the response to this question? In answering this question, please consider and comment on the response that Optus made in respect of its HFC availability in the Optus submissions.**

   In the US, cable companies provide services to residential and small and medium enterprise (**SME**) customers which compete directly with telephone companies including in respect of reliability and availability. SME customers may be supplied with services using the HFC or using fiber deployed as part of the HFC network. Many of these US cable companies have significant amounts of aerial cabling in their networks. Optus has provided its network availability rate, and I comment on this in Confidential Attachment C.

4. **What are the return bandwidth limitations in HFC networks and how are these dealt with in North America?**

   There is a significantly greater amount of return bandwidth available in Australia compared to the US. The amount of return bandwidth available per subscriber can be increased by node splitting.

5. **The Optus submissions includes comments on node splitting. Why would an HFC network engineer engage in node splitting? What are the technical issues involved and what are the associated costs?**

   A HFC network engineer would engage in node splitting when the existing HFC network capacity for interactive services such as high speed internet and telephony is approaching full utilization. The additional capacity provides opportunities for the MSO to connect more customers and grow its business. Investing in node splitting is a natural part of the evolution of a successful HFC network. Node splitting is not a complex process and has a relatively low investment cost per node. Node splitting also has the potential to reduce operational expenditure.

6. **What is the state of deployment of DOCSIS 3.0 technology in the US and could Optus deploy this technology?**

   In my opinion, the picture which emerges from the Optus submissions is of a network which has experienced under-investment over a significant period. As a result, the technology used in the network appears dated compared with standard industry practice in North America. None of the technical or engineering issues raised in the Optus submissions are unexpected or atypical of an HFC network and are routinely and successfully addressed by MSO making prudent investment and network management decisions as their businesses grow. In my view, the Optus HFC network is likely to be able to be upgraded efficiently and would then be able to support a wider range of services. This upgrade would not require a substantial investment for the reasons that I outlined in my First Report. In particular, it may be possible for Optus to "leap frog" from DOCSIS 1.1 to DOCSIS 3.0 and from its obsolete circuit switched telephony technology to a current packet switched telephony technology. DOCSIS 3.0 technology is currently under initial deployment in the US and could potentially be used by Optus to deliver innovative services over the Optus HFC network. A number of MSO are planning to engage in this form of technology leap frog process.

Content of this report

This report sets out the reasoning behind my answers set out in this executive summary. The form of the report is as follows:

- in section 3, I first give an overview of my response to reading the Optus submissions;
- in section 4, I describe the architecture and technology of the delivery of telephony using an HFC network, including upgrade pathways;
- in section 5, I discuss the issues associated with delivery of all HFC network services to multiple dwelling units;
- in section 6, I consider the reliability of HFC networks compared to conventional telephone access networks;
- in section 7, I consider return path limitations in HFC networks and use this as a platform to consider the issues associated with "node splitting" which I referred to in my First Report;
- in section 8, I consider other aspects of the Optus submissions; and
- in Confidential Attachment C, I add to my answers in sections 5 and 6 by commenting in response to Optus' confidentially provided information.

3 Initial views on the Optus submissions

3.1 On reading the Optus submissions, I was struck by the description of the state of the network in terms of investment in technology. One of my visits to Australia was in 1996 and at that time, Optus was in the process of deploying a largely state-of-the-art HFC network. That Optus has chosen to allow its network to fall so far behind normal industry practice, was a surprise to me.

3.2 A theme of Optus' response appears to be that HFC is a poor technology. That is a very different approach than that taken by cable operators in the US, who now generally consider HFC to be superior to copper networks for a range of reasons. I was surprised to see that Optus has such a low opinion of its HFC network.

3.3 It seems to me that the current network has suffered from under-investment in that the delivery of telephony and high speed data services uses technology which would have been replaced, or in the process of being migrated, if the Optus cable network had been deployed in North America. I am not aware of any comparable size network in the US which does not take advantage of more recent technology for the delivery of at least telephony services. In particular, the Motorola telephony system used by Optus and similar such systems have been replaced or are in the process of being replaced in North America as I describe in Section 4.

3.4 It would, however, be possible for Optus to use the existing HFC network and deploy current technologies. If it did this, Optus would be able to offer a wide range of services to a significantly increased proportion of the premises that its HFC network passes. That is, Optus has an opportunity to leap frog from its existing technology base to competitive current technologies.

4 Delivering telephony using an HFC network

Introduction

4.1 Telephony delivery has evolved over the last 15 years from predominantly circuit switched telephony to a combination of circuit switched and packet switched technologies. Although most telephone companies are still predominantly circuit switch based, most cable networks in North America use packet switched technologies to deliver voice services. Increasingly, telephone companies are moving along the same path.

4.2 A number of cable operators in the US offered telephony services using circuit switched technology such as that previously offered by Motorola, Arris and a corporation called ADC. These older circuit switched technologies have been, or are being, replaced by packet switched based services.

Optus telephony

4.3 From the March 2008 Submission, I understand that Optus is using the Motorola CableComm[1] system for the delivery of telephony services. This system is no longer available for the deployment of new systems and has limited support from the manufacturer. It is part of an obsolescence program.

4.4 As I set out in my First Report, there are a number of packet based voice solutions available for cable operators which represent current technology and have a significantly lower cost on a per-subscriber basis than the existing systems used on the Optus HFC network.

4.5 In my opinion, if Optus were to follow the standard practice of North American cable systems, it would replace, or start phasing out, its aging circuit switched telephony system with a packet switched telephony product. For example, the largest MSO in the US is Comcast with more than 24 million subscribers.[2] Comcast is in the process of replacing its circuit switched telephony services with packet switched telephony services as indicated in its 4Q 2007 report[3] and set out in Table 1.

Technology	Comcast subscribers Q4 2007 (million)	Comcast subscribers Q4 2006 (million)
Circuit switched	0.176	0.652
Packet switched	4.377	1.867

Table 1 – Comcast replacement of circuit switched telephony customers

1 March 2008 Submission at page 37

2 National Cable and Telecommunications Association at http://www.ncta.com/Statistic/Statistic/Top25MSOs.aspx

3 http://media.corporate-ir.net/media_files/irol/11/118591/Earnings_4Q07/Q407.htm

Telephony and MDU

4.6 I have been asked to comment specifically on the delivery of telephony services to multiple dwelling units (**MDU**). There are a number of vendors which offer customer premises equipment to address the delivery of telephony to MDU. As I mentioned in my First Report, these devices are typically combined cable modems with one, two or four telephony ports. All that is required to deliver telephony and high speed internet services to apartments in an MDU is the provision of a coaxial cable to each MDU from the HFC system and an appropriate cable modem in the MDU apartments.

4.7 In the March 2008 Submission, Optus notes that the Motorola CableComm system is not suitable for MDU in that Motorola developed a product for MDU which was not put into manufacture.[4] The industry practice in this situation would be for the HFC network operator to choose an alternative vendor which is capable of providing products to address an identifiable market need. I am not aware of other vendors that could have provided the apartment unit devices required based on the CableComm technology chosen by Optus. This is unsurprising as firstly it was a proprietary system; and secondly no vendor wants to invest in a technology that is either obsolete or due for obsolescence in the near future.

4.8 Motorola does have this type of device planned for delivery later this year based on the DOCSIS standard. This unit is called the O-eMTA. If circuit switched technology, such as Motorola CableComm, were to have continued to be a viable technology then it is likely that a similar device would have been put into production. By the late nineties, Cable operators realized that cable telephony was evolving to become DOCSIS based and there would have been little (if any) market for a unit based on the old CableComm platform.

5 Delivering HFC service to multiple dwelling units

Introduction

5.1 As I set out in 4.6 above, there are a number of vendor solutions which are specific to the delivery of services to MDU. I understand from the March 2008 submission that Optus takes the view that MDU in Australia are generally smaller than MDU in the US.[5] That is, Optus makes the point that the mix of MDU in Australia is different from the mix in the US.

5.2 I concur with Optus' broad position. For example, there is little comparison between MDU in cities such as New York and Chicago with MDU in suburbs of Sydney and Melbourne. However, there are cable systems in the US which have a very similar mix of MDU as those found in Australian suburbs. For example, in Southern California there are a significant number of MDU with four and eight premises outside of the downtown areas of Los Angeles.

North American approach

5.3 As a result of there being a wide range of MDU in the US, there are different approaches taken by cable operators depending upon the number of premises within a specific MDU. For example, a large high rise building might have a node

[4] March 2008 Submission Appendix A page 38

[5] March 2008 Submission at paragraph 3.33

located in the basement and fed to the building using fiber from the HFC network. That is, the building is treated as if it is a vertical street. At the other extreme, duplex buildings (that is, an MDU with two premises) may be connected to the cable network as if they were two single dwelling units (**SDU**), each having its own drop.

5.4 The North American cable operators deliver services to this wide range of MDU. There are no types of MDU premises which would be considered "unserviceable" simply because they are part of an MDU. There may be specific premises within certain MDU which are found to be unserviceable after inspection by a cable operator but these are uncommon.

5.5 In general, the approach in the US is to treat 2/4/8/16 unit MDU in the same way as an SDU. The lateral cable connects to each MDU unit or building from the tap and feeds a high speed internet modem which can be equipped for voice services. The coaxial cable feed is split between this device and the television and/or video set top box. The high speed internet modem can be hardwired via an Ethernet cable to the computer or the modem can also be a wireless router which can feed the entire apartment. The telephony service can be connected to a wireless telephone and feed the entire apartment. The option is to have the telephone connect (RJ-11) output of the modem hardwired/plugged into the telephone system and regular telephones used.

5.6 Clearly, the solution that is employed is dependent on the expected penetration. With low expectations of penetration, a very large block could be fed from a single drop. In the US, where there is a higher expectation of penetration than Australia, a 32 unit MDU can often be treated in the same way as the 2/4/8/16 units. Many times, however, a group of apartment complexes will have their own cable system with a central distribution location. These groups of apartments can be interconnected either by coaxial cable or fiber optics.

5.7 As an example, consider multiple MDU buildings, owned by one entity. In the Australian context, I believe that the comparable position would be if the MDU were under a single "body corporate". In this case, it may be feasible from a business perspective to build a small headend (distribution point) and interconnect each of the MDU buildings by fiber or coaxial cable. In the case of coaxial, the distribution point would consist of multiple line amplifiers fed by a coaxial drop. Each apartment would then be served with a lateral coaxial cable fed from the backbone MDU distribution cable via a tap. This is shown in Figure 1 below.

5.8 As an alternative, the distribution point could be fed by fiber and each MDU could have an optical transceiver (mini node) and the output of that transceiver would feed the backbone coaxial cable for the MDU.

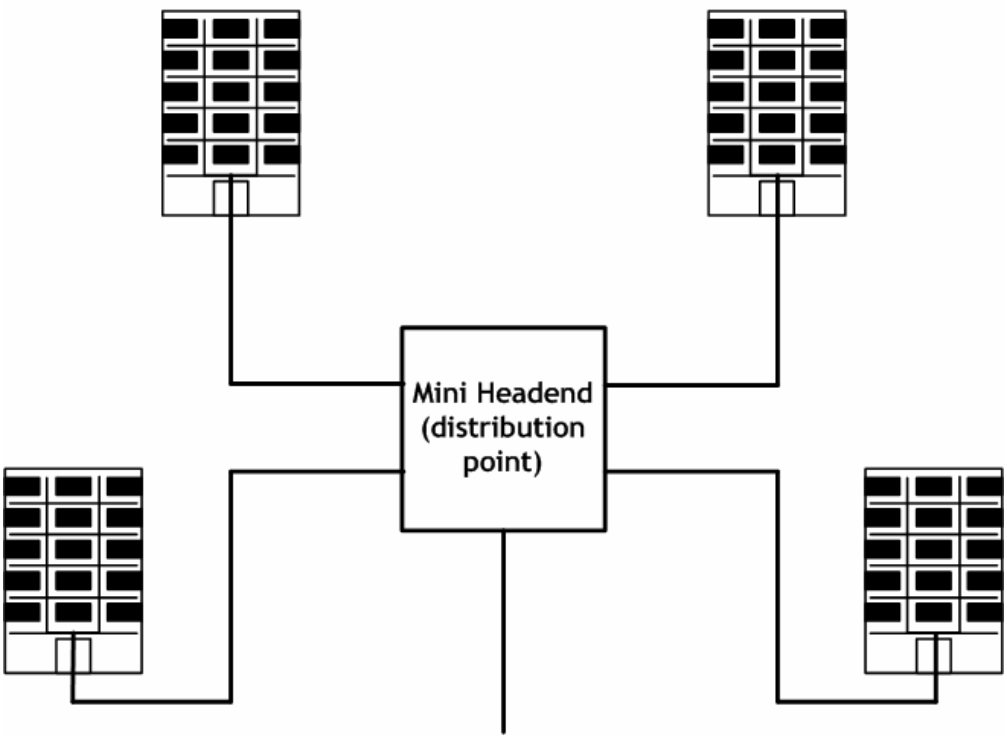

Figure 1 – Mini headend solution for multiple MDU

Optus and MDU

5.9 As I understand it, Optus has stated in the March 2008 Submission that it does not consider that MDU are serviceable by its HFC network[6] and that approximately 17% of SDU are unserviceable. I come to this view on the basis that Optus states that its HFC network passes 2.2 million premises of which 513,000 are MDU premises[7] and 287,000 are unserviceable SDU.[8] So the proportion of unserviceable SDU is 287,000 divided by 2.2 million minus 513,000 which is 287/1687 = 17%.

5.10 I further understand that Telstra regards the total proportion of unserviceable premises on their network as being approximately 7%.

5.11 In my First Report, I noted that it would be unusual to regard MDU premises as unserviceable in the North American context. In general, providing HFC network services to MDU is regarded as "low hanging fruit" in that the cost of supplying services to each MDU premise is usually lower than the cost of the provision of services to an SDU on a per subscriber basis.

5.12 From my understanding of the March 2008 Submission, Optus does not provide a rationale as to why it considers certain premises unserviceable.[9] Although labor costs have risen between 2003 and 2008, technology costs have fallen in that period. As a result, in my opinion, it would not be sound practice to rely on a

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6 March 2008 Submission paragraph 3.6

7 March 2008 Submission Appendix A page 37

8 Optus uses the proportion of SDU which are unserviceable at paragraph 3.5 (13%)

9 Based on my review of Section 3 of the March 2008 Submission

decision taken five years ago as the basis for continuing to regard such a significant portion of premises passed as "unserviceable".

5.13 If I were the engineer responsible for the Optus HFC network, I would review the 2003 decision not to service 36% of the premises passed by my network.

5.14 In particular, having reviewed the confidential information provided, I believe that Optus' assumed costs (both fixed and variable) of connecting MDU are higher than what would be necessary from an engineering point of view. I make further observations and comments relating to Optus' approach to MDU in Confidential Attachment C.

6 Reliability of HFC networks

Introduction

6.1 As I understand the March 2008 Submission, it is Optus' contention that an HFC network is inherently not as reliable as a copper pair based telephony network.[10] That is, the availability and reliability of an HFC network is too poor to permit the delivery of business and other services.

6.2 It seems to me that this position is based on Optus' view that its HFC network is not as reliable as the copper network. This view is not one which is accepted generally by North American cable operators in respect of their networks.

6.3 I have reviewed Optus' HFC network availability rate (provided to me on a confidential basis) and I provide comments on this in Confidential Attachment C.

6.4 In the US, MSOs offer residential and small and medium enterprise (**SME**) telephony services along with multi-channel video and high speed internet services on the basis that they are direct replacements for telephone company offerings based on their copper loops including voice and digital subscriber line (**DSL**) services.

6.5 SME customers may be supplied with services using the HFC network or using the fibers/wavelengths from that network depending on the types and volume of services required by the SME business. As I mentioned in my First Report, delivery of services to businesses is seen as a very important next step for additional revenues.[11]

Aerial cable

6.6 I also understand that Optus takes the view that the fact that its HFC network is predominantly aerial, means that it is less reliable than an underground network.

6.7 Clearly, aerial cable is more likely to be adversely affected by high winds and hail. However, there are 2 concepts which are associated with the availability of a network. These are the mean time between failures and the mean time to repair. In an aerial cable network, adverse weather may lead to a shorter time between network failures. However, aerial cabling is relatively easy to repair as all parts of the cable are accessible. When underground cabling is damaged, the

[10] March 2008 Submission paragraph 2.11

[11] First Report paragraph 6.5

time to repair is likely to be significantly longer than the equivalent time for aerial cabling. Underground cables can be damaged by rodents, water ingress and "backhoe fade". That is, there is a risk of underground cables being inadvertently dug up and this can cause lengthy unavailability of a service.

6.8 As part of my preparation of this report, I contacted Cablevision Systems Corporation (**Cablevision**) to find out about the proportion of aerial cable used by that MSO. Cablevision is the fifth largest MSO in the US with more than 3 million subscribers.[12] Cablevision reported that the breakdown of the Cablevision outdoor plant is:

Aerial	32,000 miles (about 51,200 km)
Underground	8,200 miles (about 13,120 km)

That is, 74% of the outdoor cable plant is aerial.

6.9 This high proportion of aerial plant has not prevented Cablevision from achieving great success in providing telephony and high speed internet services to its customers. Based on Cablevision's annual report (SEC filing 10-K)[13] which was published on 28 February 2008, the proportion of customers who took a high speed internet services was 69% of total customer base and the proportion taking telephony services was 48% of total customer base.

7 Return path issues

Introduction

7.1 Optus notes in the March 2008 Submission that its network is typically based on up to one node per 2,000 homes passed.[14] Optus also notes that it requires 6 MHz for the delivery of cable telephony services.[15] The requirement for upstream capacity and the large number of premises passed per node, indicates that there may be a need for "node splitting". I have been asked to comment on these issues and to explain the concept of node splitting.

7.2 Before providing my views on the matters raised by Optus, I would note that, from an engineering perspective, a system where nodes have to be split is a successful system. That is, node splitting is a good indicator that subscribers are taking more services and a wider range of services. In particular, it indicates that subscribers are taking, among other things, high speed internet and telephony services. Investment in node splitting is likely to be justified on the basis that the existing network has nearly exhausted its capacity along with a high probability that the additional capacity will be utilized. That is, what Optus apparently sees as a troublesome and expensive problem, would be treated by MSO in the US as a sign of success.

7.3 Another aspect of the approach to node splitting in the US is that cable networks are usually designed to scale to an increasing number of customers and services. This means that there is excess fiber deployed to node locations to permit future node splitting and the delivery of additional services. North American operators

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12 National Cable and Telecommunications Association at http://www.ncta.com/Statistic/Statistic/Top25MSOs.aspx

13 Annual report at http://www.cablevision.com/investor/sec.jsp

14 March 2008 Submission paragraph 2.18(a) sets this out as a multiplier of Telstra's 500 homes passed per node

15 March 2008 Submission paragraph 2.18(a)

typically perform advanced planning and node size analysis. Most MSO designed much smaller node sizes than Optus but did not initially take advantage of them. Instead, they combined lasers at the headend and fed them to multiple nodes throughout the system. When justified by traffic needs, they separated these combined nodes and replaced their CMTS ports and optical connections.

7.4 Another example of "advanced planning" is that when I built the fiber optic system to service the San Juan Puerto Rico cable system in approximately 1995, I built the fiber optic rings, and other portions of the cable network, so they would not only be able to service the existing cable system but also business locations. This does not necessarily require the fiber rings to directly pass these businesses, because if there is sufficient fiber capacity in the network, then "one-shot fiber" extensions can be used to feed these locations. Good practice suggests that a fiber optic based network such as Optus' would, during initial construction, include sufficient fiber capacity to allow for additional customers to be served this way.

Node splitting

7.5 In this section, I first outline how node splitting occurs before providing some cost estimates associated with node splitting in the US. I then go on to analyze the issues that Optus has raised in respect of both node splitting and return paths.

7.6 In my First Report, I introduced the concept of node splitting. To recap, node splitting reduces the number of homes passed per node and concurrently increases both the forward and return path interactive (for example, high speed internet and telephony) spectrum available per user. I now provide a more detailed description of the reasons for node splitting.

7.7 The principle reason for splitting a node is to provide for better shared bandwidth for the services which require an upstream capability. In general, these are interactive services such as telephony and high speed internet which require two way traffic. This is in contrast to broadcast only services that can be shared with everyone on a particular cable system. Services such as telephony and high speed Internet services require two way interaction and specific bandwidth directed to individual groups of customers.

7.8 I will use as an example the delivery of high speed internet services. When customers use their high speed internet service connection, they share upstream and downstream bandwidth. If there is a single DOCSIS carrier dedicated to high speed internet on a cable system node it will provide approximately 30 Mbit/s[16] of data shared between all of the customers who are served from that particular node. It does not matter how many people on that node are using the high speed internet service concurrently, they all share the same bandwidth. The more people who use the data carrier the lower the average data rate per customer.

7.9 Node splitting minimizes this problem. If there are 2,000 homes passed from a single node, and 500 high speed internet service users on that node, the 500 users are all sharing the same bandwidth. By splitting the node by a factor of four, then there will be 500 homes passed from that node and, assuming the ratio stays the same, 125 high speed internet service users sharing a 30 Mbit/s DOCSIS carrier. In practice, a node split does not precisely split the number of

[16] First Report paragraph 4.16

users for any particular service. In this report I use the mathematical division as an example of the outcomes from node splitting.

7.10 By splitting the node different DOCSIS carriers can be injected into each fiber optic feed, received by separate optical receivers in the node, distributed by different launch amplifiers into coaxial feeds servicing different groups of customers. Shown in figure 2 below is a four output node before subdivision. One downstream wavelength is servicing all four outputs of the node. Each output then feeds a coaxial cable passing 500 homes

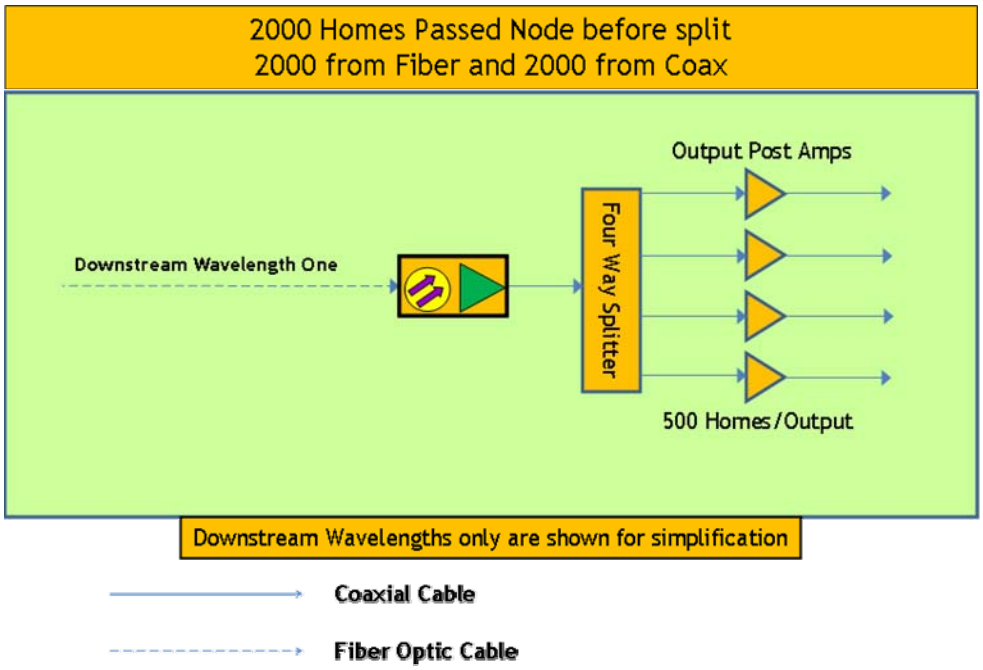

Figure 2 – Typical node feed arrangement before node splitting

7.11 Another example of forward planning was an approach taken by many operators in the US. There was no initial need for large amounts of interactive bandwidth so the approach was taken to build down to 500 homes passed per node but to use common lasers to feed multiple nodes. Figure 3 shows two nodes (although three or four nodes were also treated in this fashion), each serving 500 homes, but being fed by a single laser and DOCSIS carrier. As traffic increased these were separated into individual nodes being fed by different lasers and DOCSIS carriers.

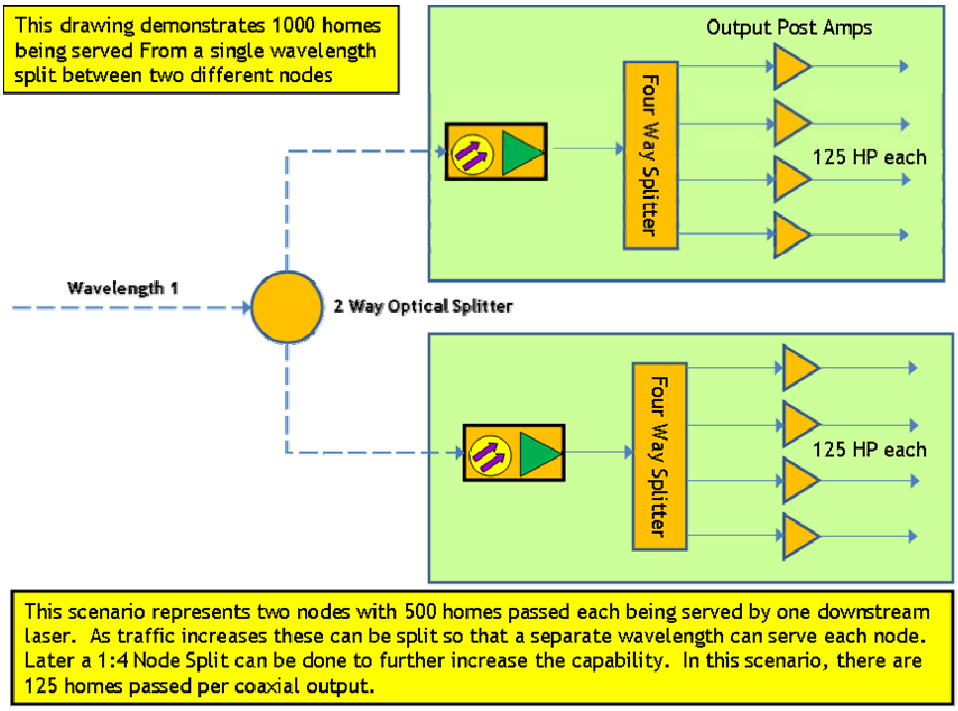

Figure 3 – Typical node with forward planning

7.12 Node splitting requires investment in replacement node electronics and may require some reworking of the outdoor coaxial plant.

7.13 Consider a node that is delivering services passing 2,000 premises. This node will typically have one fiber dedicated to downstream and one fiber dedicated to upstream traffic. In addition, it is typical to have further, spare fibers reserved for future requirements.

7.14 In the case of this typical node, node splitting could occur by changing out this single node with one that has four optical receivers feeding four separate output amplifiers. Instead of having one fiber for downstream and another for upstream, four fibers can be used for the upstream and downstream delivery of services to each node. This is done using a technology called coarse wavelength division multiplexing (**CWDM**) which is shown in Figure 4 below. Each fiber carries one wavelength in the downstream direction (to the node) and one wavelength in the upstream direction (away from the node).

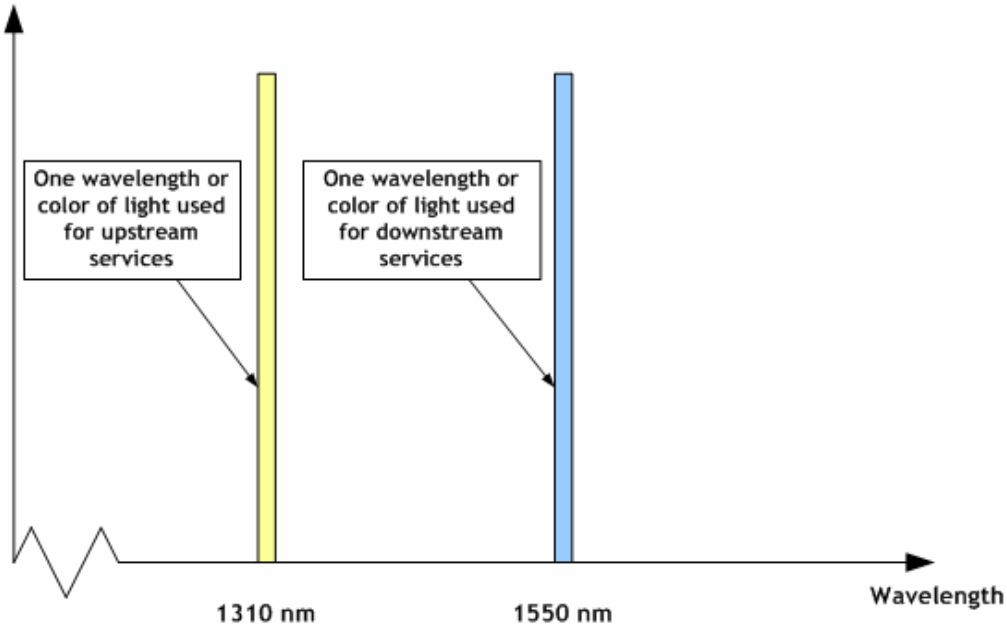

Figure 4 – Coarse wavelength division multiplexing

7.15 In addition to the node splitting, there needs to be a further investment at the headend to replace the optical transmitters and receivers with coarse wavelength division multiplexing equipment.

7.16 A simple example of this would be a single node location, feeding four coaxial outputs with common services, that has been split into four discrete nodes with each coaxial output being fed with material which is specific to the customers on that output. Each of these coaxial outputs serves 500 homes passed. If there is no need to split by a factor of four then splitting a node by two or three is also feasible at reduced cost. The cost of the electronics for replacing the existing single optical node, with a four optical node, is approximately US$6,500. There will be additional expenditure in the headend, such as lasers and related CWDM devices, and the labor costs associated with installation. A simple example of the replacement nodes is set out in Figure 5 below.

7.17 Node splitting also has the advantage of reducing the likelihood of system failure affecting any particular customer and, as a result, could reduce operational expenditure.

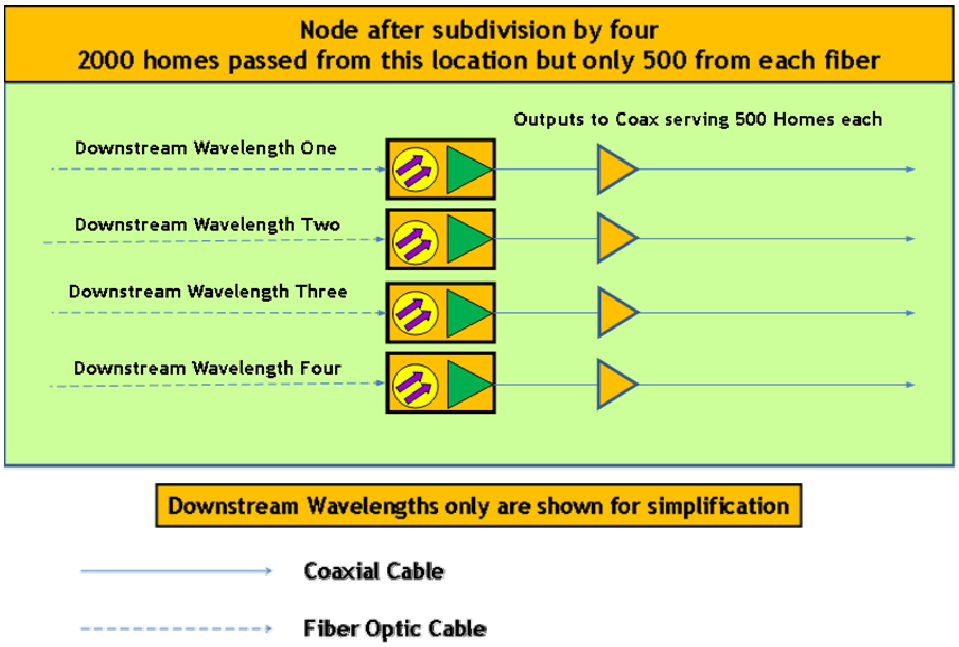

Figure 5 – Replacement nodes

7.18 There is another option being offered by the US based company InnoTrans Communications. InnoTrans has a cost effective technology for delivery of four wavelengths downstream and four wavelengths upstream on a single fiber for distances up to 40 km. Using this technology a four way node subdivision could be done using a single fiber. InnoTrans also offers a product for delivery of 8 or 16 wavelengths on a single fiber for shorter distances. There are many other options for doing node subdivision in low fiber count situations depending on the distance.

Return path

7.19 As I set out in my First Report, the return path bandwidth available in Australia is significantly larger than that available in North America. Optus has not taken issue with this aspect of my First Report. Clearly, if Optus chooses to share this return path bandwidth between 2,000 premises passed (of which, on average, Optus would say that 1,280 are serviceable) then there is a limit to the number of concurrent services. However, as I mentioned above, cable operators would normally regard the requirement to split nodes as an indicator of success. If Optus were to split nodes to serve 500 premises passed, then it would not be significantly limited in the provision of high speed internet and telephony services.

8 DOCSIS 3.0 rollout in the US

8.1 In the March 2008 Submission, Optus appears to have indicated that it is reluctant to change from the DOCSIS 1.1 technology to DOCSIS 3.0 technology.[17] I understand that there are costs associated with the replacement of the cable modem termination system (**CMTS**) in order to deploy DOCSIS 3.0 technology. However, there has been a significant move towards the deployment of

[17] March 2008 Submission paragraph 2.18(c)

DOCSIS 2.0 and DOCSIS 3.0 services in the US. Some North American MSO have converted to DOCSIS 2.0 but others have decided to wait for DOCSIS 3.0 technology.

8.2 As an example of the more general deployment of DOCSIS 3.0 technology in the US, I set out in Table 2 below some information as to recent trends in DOCSIS 3.0 technology deployment.

MSO	Rank[18]	Announcement
Comcast	1	29 November 2007: Comcast CTO Tony Werner told attendees at CableNEXT Conference in Santa Clara that the company hopes to have DOCSIS 3.0 technology in place in around 20 percent of the company's footprint by the end of next year.
Time Warner Cable	2	4 April 2008: New Paradigm Resource (a technology deployment tracking business) reported that Time Warner Cable is expected to begin deploying DOCSIS 3.0 later this month.
Cox Communications	3	20 March 2008: John Coppola, Cox's director of access technology and engineering, "Cox plans to do some limited deployments of DOCSIS 3.0 in the second half of 2008" in Light Reading Cable Digital News.
Charter Communications	4	27 February 2008: "We plan to test next-generation DOCSIS 3.0 in the second half of this year," said CEO Neil Smit during an earnings call with reporters and analysts.

Table 2 – DOCSIS 3.0 deployment

8.3 In addition, there have been a number of announcements from equipment vendors on the availability of DOCSIS 3.0 technology based products for business applications. Examples of these include SMC Networks[19] and Arris.[20] Another company RAD Data Communications has announced new products for business applications compatible with current DOCSIS technologies.[21]

[18] By subscriber numbers. Source National Cable and Telecommunications Association at http://www.ncta.com/Statistic/Statistic/Top25MSOs.aspx

[19] http://www.lightreading.com/document.asp?doc_id=151667&site=cdn

[20] http://www.arrisi.com/press_events/press_releases/pressdetail.asp?id=398

[21] http://www.rad.com/Article/0,6583,20605,00.html

Attachment A — Resume of Michael Harris

Michael G. Harris

Harris Communications Consulting LLC

16 Gorge Lane
Pound Ridge, NY 10576

PROFESSIONAL EXPERIENCE

06/07-Present Member of CommScope Broadband Technical Advisory Board

Primary Responsibility:

- Evaluate new and existing products.
- Develop new products.
- Evaluate possible acquisitions.
- Provide training for in-house personnel.

03/06-05/07 Consulting to Allied Capital/Longview Cable for Cable TV Operations

Primary Responsibility:

- Evaluated equipment for system rebuilds.
- Reviewed rebuild specifications and construction practices.
- Evaluated various systems for possible purchase.
- Reviewed Proof of Performance reports.
- Reviewed CLI reports.

(note: Allied Capital decided earlier this year to sell all their existing operations)

03/05-Present Consulting Services to Diamond Castle Holdings, LLC. for Cable TV, Cellular and other acquisitions

Primary Responsibility:

- Evaluated various systems for possible purchase.
- Reviewed construction practices.
- Reviewed Proof of Performance reports.
- Reviewed new construction certification reports.
- On site inspection of new under grounding activities relating to system rebuild.

- Reviewed CLI reports.
- Projected on-going extraordinary capital expenditure requirements.

10/99 –12/04 Senior VP Engineering and CTO Citizens Communications

Responsibilities Included:

- Evaluated new technologies for use in Citizen's network with over 2.4M subscribers.
- Evaluated video over DSL equipment and suppliers.
- Lead on multi-company consortium for deployment of video services.
- Total responsibility for Citizens Cable TV systems which included the following:
  - All FCC matters including Proof of Performance, CLI and public file.
  - All rebuild, new build and upgrade specifications for electronics and physical construction.
  - All Headend specifications, equipment selection and construction.
- Responsible for Capital Expenditure Tracking and Control for entire company.
- Lead on our Capital Review Committee meetings for project approval.
- Developed and Maintained Capital Approval Matrix and policies.
- Capital budget review and approval responsibility.

1973 – 1999 Senior VP Engineering/CTO Century Communications

Responsibilities Included:

- All engineering activities for Century's 1.7 Million Cable TV subscribers which included:
  - FCC proof of performance format, testing, documentation and final review.
  - CLI reporting and documentation and certification for both aerial and ground based tests.
  - General construction practices.
  - System design for both new build and rebuilds.
  - Capital reporting and tracking to budget.
  - Evaluation of new technologies.
  - Developed electronics lab for the manufacturing of amplifier replacement modules. (1973 through 1985)
  - Member of Century's Board of Directors.

*Century had approx 72 Cable Systems across the US and Puerto Rico. We were the largest Cable Operator in the Los Angeles/Orange County area. We were also the largest Cable Operator in Puerto Rico.

1989-1997 Senior VP Engineering/CTO Centennial Cellular.

- Total responsibility for Centennial's initial entry into Cellular Telephone Business.
- Initial deployments included:
  - Lincoln, NE
  - Yuma, AZ
  - El Centro, CA
  - South Bend, Huntington & Ft. Wayne, Indiana.
  - Kalamazoo, Battle Creek & Benton Harbor, Michigan.
  - Greater San Juan, Puerto Rico. We were one of the first companies to select and deploy CDMA Cellular Technology.
  - At the time of sale the company had approximately 10M POPS.

*Centennial Cellular was a division of Century Communications.

1971-1973 Northwest Regional Engineer for Teleprompter Corporation

- Total engineering responsibility for Cable TV systems located in the NW Region.
- Developed the first FCC Proof of Performance reporting documents for Teleprompter.
- Responsibility for all System and Headend Construction and Certification.

*Teleprompter, at that time, was the largest Cable Television Operator in the US with 1.1 Million subscribers.

1967-1970 US Army (35H20) RA50203023

- Boot camp at Fort Lewis, Washington.
- Mathematics and Electronics Teacher at Aberdeen Proving Grounds, Maryland.
- Mathematics and Electronics Teacher at Corpus Christi NAS, Texas
- Director of the Army Calibration Lab on the USNS Corpus Christi Bay located in Vung Tau, Vietnam.
- Awarded the Bronze Star in 1970.

1966-1967 RCA Service Company/White Alice Project-Anchorage, Alaska.

- Maintained a Forward Propagation Tropospheric Scatter Transmitter, and related Telephone and Teletype equipment, at Cape Newingham, Alaska. This was pre-satellite technology and phase out was started in the early 1970's.

EDUCATION

Columbia Basin College – AAS Electronics Technology	1964-1966
US Army Electronics and Calibration Technology School (35H20)	1967/1968

MEMBERSHIP IN PROFESSIONAL GROUPS AND ORGANIZATIONS

Society of Cable Television Engineers	1981-Present
Society of Cable Television Pioneers	1996-Present
American Radio Relay League	1972-Present
Ham Radio Operator (Extra Class Call W1MH)	1961-Present
Loyal Order of the 704 Society	1997-Present

Attachment B — Federal Court Guidelines

Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia

This replaces the Practice Direction on Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia issued on 6 June 2007.

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

5 May 2008

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 (footnote #1), and to assist experts to understand in general terms what the Court expects of them. 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 (such as that of treating medical practitioner or a firm's accountant) between the author of the report, or his or her firm, company etc, and a party to the litigation.

An expert is not disqualified from giving evidence by reason only 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.

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.

Some expert evidence is necessarily evaluative in character and, to an extent, argumentative. Some evidence by economists about the definition of the relevant market in competition law cases and evidence by anthropologists about the identification of a traditional society for the purposes of native title applications may be of such a character. The Court has a discretion to treat essentially argumentative evidence as submission, see Order 10 paragraph 1(2)(j).

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

Nothing in the guidelines is intended to require the retention of more than one expert on the same subject matter – one to assist and one to give evidence. In most cases this would be wasteful. It is not required by the Guidelines. Expert assistance may be required in the early identification of the real issues in dispute.

Guidelines

1 **General Duty to the Court** (footnote #2)

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

1.2 An expert witness is not an advocate for a party even when giving testimony that is necessarily evaluative rather than inferential (footnote #3).

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 (footnote #4)

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 and state the qualifications of each person who carried out any tests or experiments upon which the expert relied in compiling the report.

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

2.5 The expert should give the reasons for each opinion.

2.6 At the end of the report the expert should declare that "[the expert] has *made all the inquiries that* [the expert] *believes are desirable and appropriate and that no matters of significance that* [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 that 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 (footnote #5).

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 (footnote #5).

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 (footnote #6).

3 Experts' Conference

3.1 If experts retained by the parties meet at the direction of the Court, it would be improper 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.

footnote #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].

footnote #2

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

footnote #3

See Sampi v State of Western Australia [2005] FCA 777 at [792]-[793], and ACCC v Liquorland and Woolworths [2006] FCA 826 at [836]-[842]

footnote #4

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]

footnote #5

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

footnote #6

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

Confidential Attachment C – Commercial-in-confidence