

Telecommunications Carriers' Forum

Dual Feed: Review of Technical Elements for the New Zealand Telecommunications Environment

4 July 2008

Preliminary Assessment of Performance Impacts of Using a Modified PSD for ADSL2+ at Cabinets in Dual Feed DAs

Introduction:

1. The NZ IMP currently states that Deployment State B is the default state for dual feed areas i.e. geographic areas that are served from more than one location.
2. In the NZ context of DSLAMs potentially being located at both the exchange and a cabinet, Deployment State B implies that the DSLAM(s) in the cabinet could operate at full power, which would have a detrimental effect on any exchange launched services to the same area.
3. Some Access Seekers have indicated renewed interest in the possibility of giving exchange launched services priority in a dual feed scenario.
4. The purpose of this presentation is to provide an indication of the effect on DSL line rates if exchange priority was implemented in dual feed areas.
5. Note that the exact line rates in any particular scenario depend on the modelling assumptions made and vary according to the distance from the cabinet to the exchange and from the end customer to the cabinet.

Performance prediction

6. The level of Interference from other systems operating in the same cable binder varies between pairs depending on normal cable manufacturing tolerances and how the individual conductors are grouped together in the binder during the cable manufacturing process.
7. International best practice is therefore to measure a large sample of pairs with cable binders of the same type and determine the 1% worst case interferer. Worst case performance predictions are then calculated assuming the victim is in the presence of 1% worst case interferers.
8. The actual level of interference experienced by any in service transmission system on the network cannot currently be easily determined at any point in time. If the 1% worst case crosstalk is used to design the system then an operator can be confident that very few transmission systems deployed can be expected to require rework due to higher than expected interference.
9. For bit rate insensitive services, such as broadband, any DSL system operating at a line bit rate lower than expected may not materially impact the service experience. However where DSL technologies are used to deliver services sensitive to line bit rate (such as streaming video) then the service experience can be very materially impacted if the link performance is below the design limit.
10. The NZ IMP benchmark performance is calculated using 20 1% worst case disturbers and industry best practice based mathematical models.

11. Performance predictions in this paper assume that the FSAN formula is used to determine the total NEXT and FEXT. Overall noise is the arithmetic sum of NEXT, FEXT and thermal cable noise. This will be referred to simply as 'reference noise' performance.

Dynamic vs. Static Spectrum Management

12. Dynamic Spectrum Management refers to the ability to be able to respond to changing noise environments in a binder in real time
13. In Cioffi et al., "Vectored DSLs with DSM: The road to ubiquitous gigabit DSLs", WTC 2006, four levels of DSM are defined

DSM level	Description
0	No DSM
1	Single-line PSD control
2	Multi-line PSD control
3	Multi-line vectored DSL

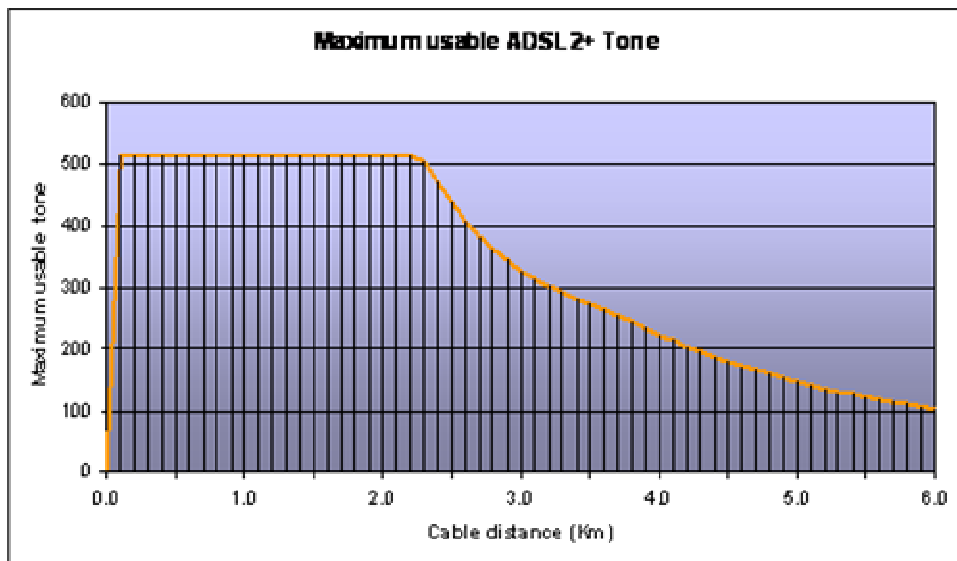
14. DSM level 2 and 3 is at an early stage of standardisation. "Elements" of mechanisms required for DSM level 2 and 3 appear in existing ADSL2+ and VDSL2 standards to varying degrees.
15. To implement DSM3, enhancements to existing service provider's equipment (DSLAMs) and infrastructure will be required, especially the addition of a "Spectrum Management Centre" to coordinate, in real time, power use across all provider's lines operating in the same binder.
16. It is not envisaged that DSM level 2 or 3 techniques will be practical for dual feed cabinets at this time, but are identified as an option for the future, since they may enable significantly greater bit rates within existing bandwidth.
17. Only static spectrum management (DSM Level 1) will therefore be considered for dual feeding at this time.

Shaping of the Cabinet Power Spectral Density in Dual Feed

18. The static approach on sub loops in dual feed scenarios, where the performance of exchange launched systems must remain unaffected, is to shape the Power Spectral Density profile of the cabinet launched systems.
19. At a given cabinet range from the exchange, the PSD of the cabinet based system is modified to closely resemble the PSD shape of exchange launched systems at the cabinet location.
20. For cabinets that are beyond the operating range of the full ADSL2+ band, the maximum usable frequency of ADSL2+ systems is determined and tones above that frequency (subject to appropriate transitional PSD slopes) can then be used at full power from the cabinet boosting cabinet launched ADSL2+ performance.
21. Shaped PSD ADSL2+ based systems make use of mandatory features in the ADSL2+ standard for modifying their PSD.
22. PSD shaping features are not part of the ADSL1 standard and so no equivalent capability exists when a standards based system is operating in ADSL1 mode.
23. The only power control feature in ADSL1 is to reduce the power across the entire operating ADSL1 band, by up to a maximum of 12db below nominal using the politeness power back off attenuator.
24. Telstra deploys dual feed ADSL1 mode cabinet launched systems today in Australia using external filters to modify the ADSL1 PSD.
25. At least one vendor (Nokia Siemens Network) has stated that it would be able to supply cabinet equipment that is capable of PSD shaping when operating in ADSL1 mode. Information from other vendors has not been forthcoming.
26. All Alcatel Lucent DSLAM's currently deployed by Telecom do not support PSD shaping in ADSL1 mode.

Maximum Usable Frequency

27. The chart below shows the highest tone that is usable by an exchange launched ADSL2+ victim as a function of range from the exchange on NZ 0.4 PEFUT cable (in the presence of 10 exchange launched ADSL2+ disturbers).
28. Where all tones are usable at the cabinet range, then any ADSL2+ systems launched from the cabinet with a modified PSD will achieve a slightly better performance than an exchange launched service to the same location, provided the pair from the cabinet to the end user is not connected to any pair between the exchange and the cabinet, or a filter is inserted at the cabinet between any exchange pair and the pair beyond the cabinet.
29. Where the maximum usable tone at the cabinet range is less than the maximum tone supported by the transmitter, then tones above the maximum usable can be used at full power from the cabinet to improve the achieved performance of cabinet launched systems.



30. ITU-T G997.1 recommends that instead of calculating the highest frequency that can carry bits in a worst-case benchmark scenario, that instead a minimum signal strength threshold is agreed and the Maximum Usable Frequency (MUF) is then the lowest frequency from the exchange that falls below that threshold at the cabinet location.

Performance issues with ADSL1 mode and shaped PSD ADSL2+ from the cabinet

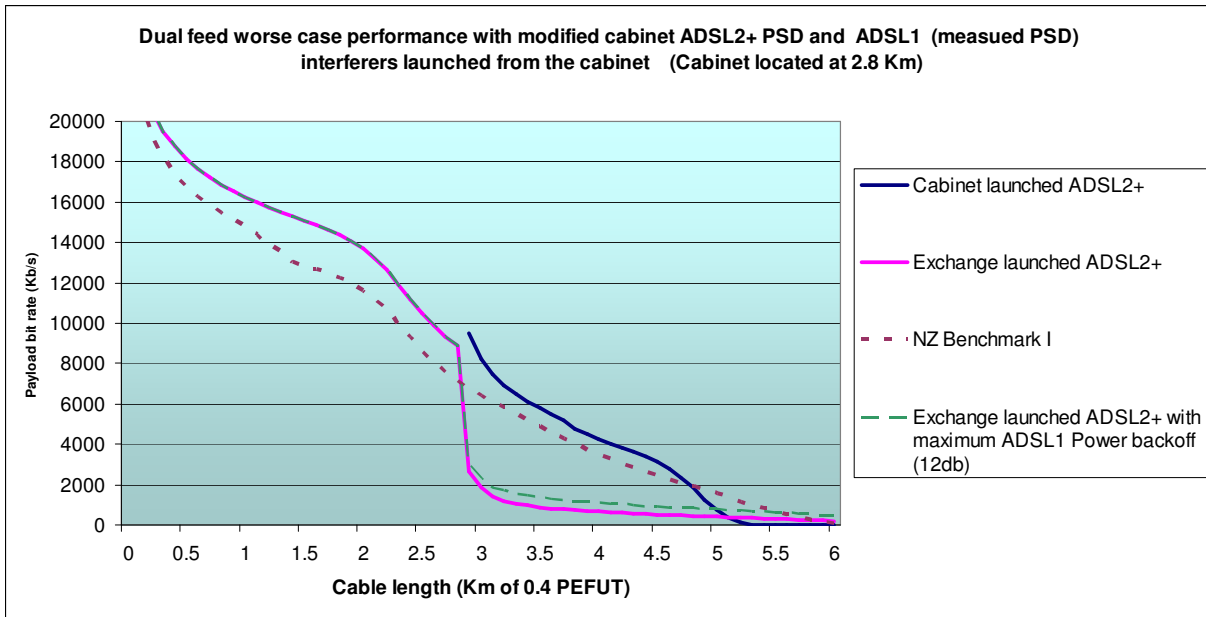
31. Forty five percent (45%) of Telecom ADSL ports currently in use support ADSL2+. Of these, 46% are operating in ADSL1 mode, presumably because the modems in use on those lines only support ADSL1 mode.
32. If an ADSL1 modem is connected to an ADSL2+ DSLAM line circuit, that supports the ADSL1 mode, then that modem will synchronise using the ADSL1 mode.
33. If the ADSL1 mode is permitted to be used from a dual feed Cabinet without appropriate spectral shaping, then the impact on exchange launched ADSL2+ systems can be severe for exchange launched lines operating beyond the cabinet when a number of cabinet launched ADSL1 mode lines are operating in the same binder as the ADSL2+ line.
34. Similarly, without spectral shaping, cabinet launched systems operating in the ADSL1 mode also impact the achievable downstream performance of cabinet launched ADSL2+ systems in the same binder.
35. Without spectral shaping, the severity of the impact of ADSL1 mode lines on ADSL2+ lines increases the further the cabinet is from the exchange.

Examples for a cabinet located 2.8 km from the exchange

36. The impact on ADSL2+ lines has been simulated for the case where the cabinet is 2.8Km from the exchange.
37. The cabinet distance of 2.8 Km is chosen for this example because this is the average cabinet range for the cabinetisation programme Telecom has recently given notice for.
38. The PSD mask for cabinet launched systems in this example has been calculated by;
 - a. Applying the NZ PEFUT 0.4mm cable attenuation (as published in the NZ IMP) for 2.8Km of cable to the ADSL2+ Annex A nominal PSD without ripple,
 - b. Assuming all tones can be reused at full power (after a transitional PSD slope) where those tones are calculated to not carry any bits on exchange launched systems when in the presence of 10 exchange launched ADSL2+ disturbers.
 - c. A low power override is implemented as proposed by Vodafone NZ as outlined in ITU-T G997.1 (ref appendix 3)
39. It should be noted that this is not fully consistent with industry recommendation as real systems require an additional slope in PSD mask transitions.
40. If a shaped PSD approach was to be recommended by the working group, agreement would need to be reached on the actual final masks to be adopted and agreed performance benchmarks determined for this case. Further improvements in performance of cabinet launched services over the PSD mask (defined in Appendix 1), would be possible through a process of optimising the spectral masks, without causing the performance of exchange launched services to fall below the benchmark.
41. These examples are simplified PSD shape examples only to provide an indication of the relative impacts. The PSD shapes assumed are given in Appendix 1

Predicted worse case performance with ADSL1 and ADSL2+ mode from the cabinet

- 42. The following is the predicted downstream performance in the reference noise benchmark scenario.
- 43. 10 cabinet launched ADSL1 interferers and 10 ADSL2+ exchange launched interferers in the binder have been assumed. The ADSL1 interferers do not use spectral shaping.
- 44. The ADSL1 power spectral density used is the “measured PSD” given in appendix 1. The lower power ADSL1 case is with the measured PSD reduced by 12dB(the maximum supported in the ADSL1 standard)
- 45. The impact of the non-shaped ADSL1 cabinet launched interferers on an exchange launched ADSL2+ victim operating beyond the cabinet is severe.

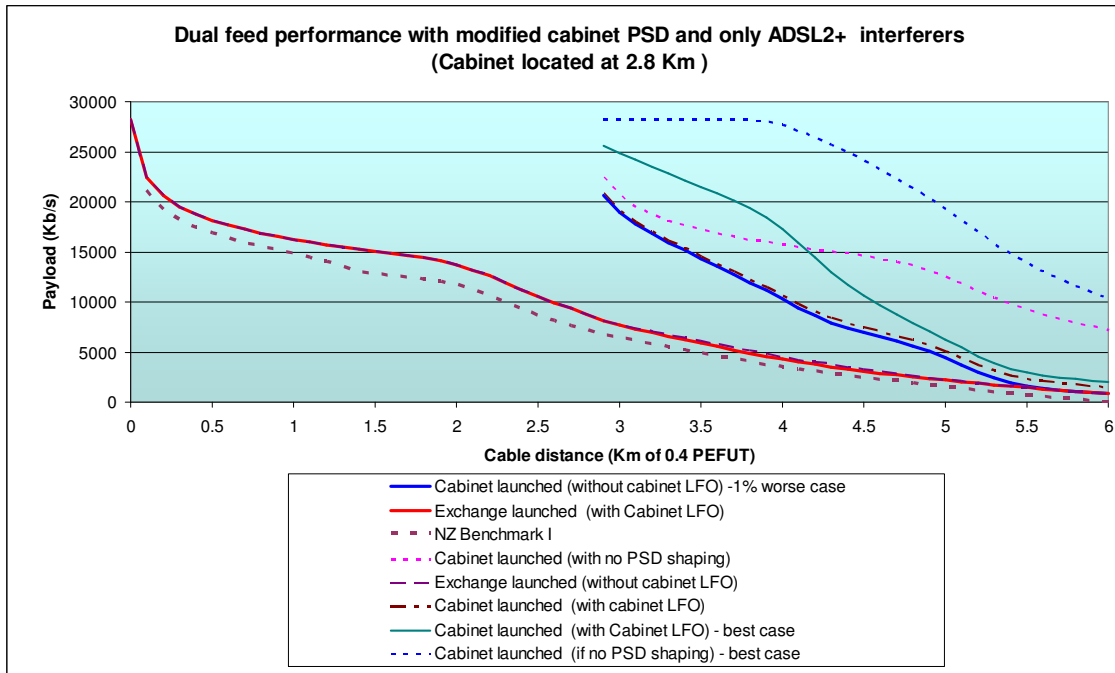


Predicted worse case shaped ADSL2+ performance if ADSL1 mode is not permitted

46. The following graph shows the predicted performance for exchange and cabinet launched systems at the “average” proposed cabinet range (2.8Km) if the ADSL1 mode is not permitted from the cabinet (i.e. ADSL2 and 2+ only on cabinet launched lines) with a shaped PSD for cabinet launched services.

47. Two options for cabinet spectrum shaping are considered. These are
- a. With LFO: A Low Frequency Override (LFO) boosting power on lower frequencies above those in (b) up to a set frequency.
 - b. Without LFO: Lower frequencies set to match the exchange launched PSD as seen at the cabinet below the maximum usable frequency

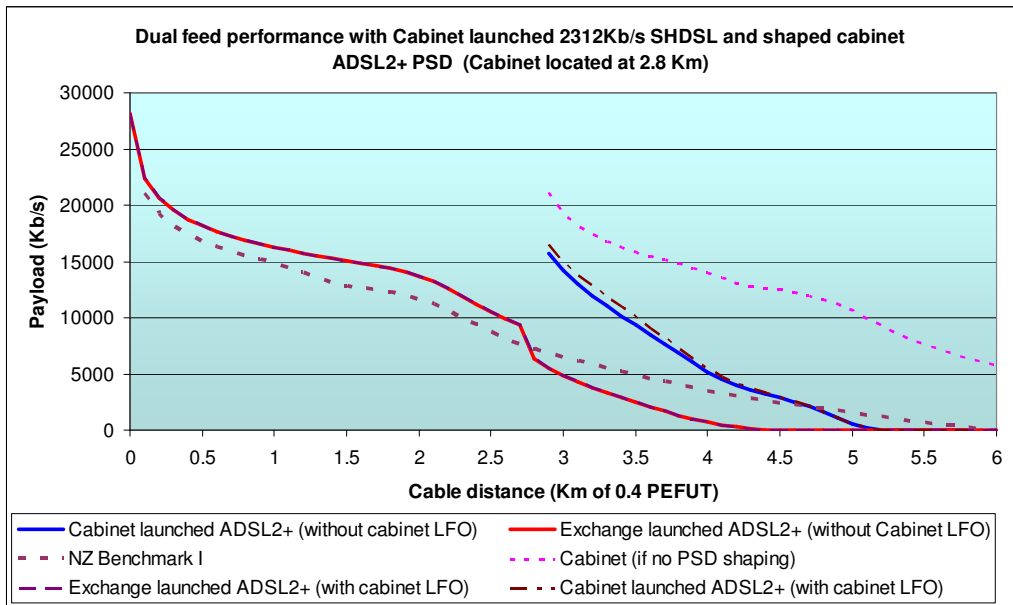
48. The graph includes both reference noise performance and ‘best case’ performance, which assumes no co-located interferers are present (although a background noise level of -140dBm is still assumed).



Cabinet bit rate reduction due to PSD shaping		
Cabinet loop	% reduced	
	1% Worse case	Best case
500m	11%	19%
1000m	25%	31%
1500m	44%	50%

Predicted shaped ADSL2+ performance if 2312Kb/s SHDSL is launched from the cabinet

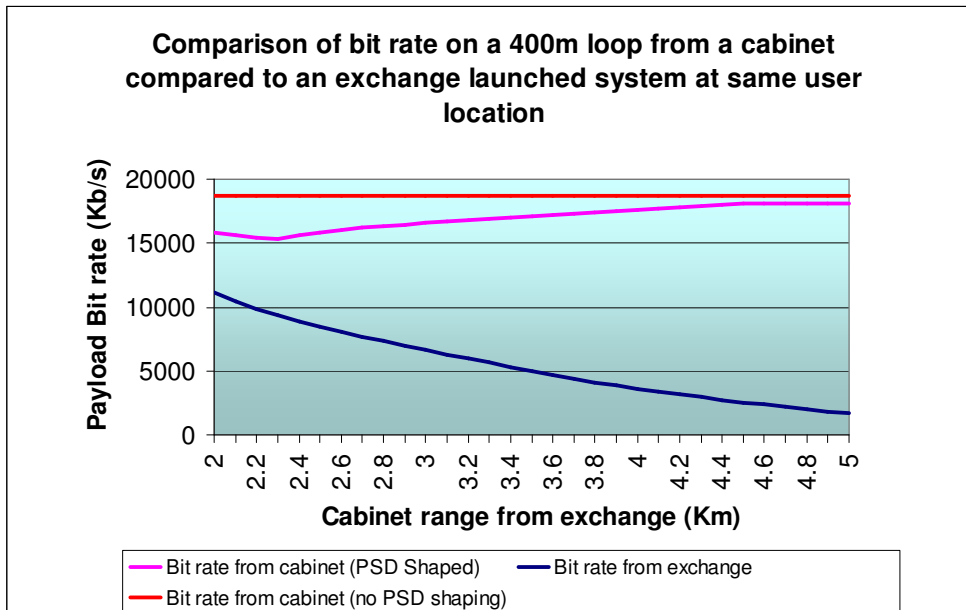
- 49. The following graph shows the predicted performance for exchange and cabinet launched systems at the “average” proposed cabinet range (2.8Km) if 2312Kb/s SHDSL is launched from the cabinet.
- 50. If performance from the exchange must be preserved then cabinet launched SHDSL could not be permitted.
- 51. Even if exchange ADSL2+ performance could be partly sacrificed, the permitted reach of cabinet launched symmetric non DMT technologies would need to be severely constrained.



Comparison of the three options for a user 400m from a cabinet location

52. The following graph shows the predicted performance for a user that is 400m from a cabinet for each cabinet range.

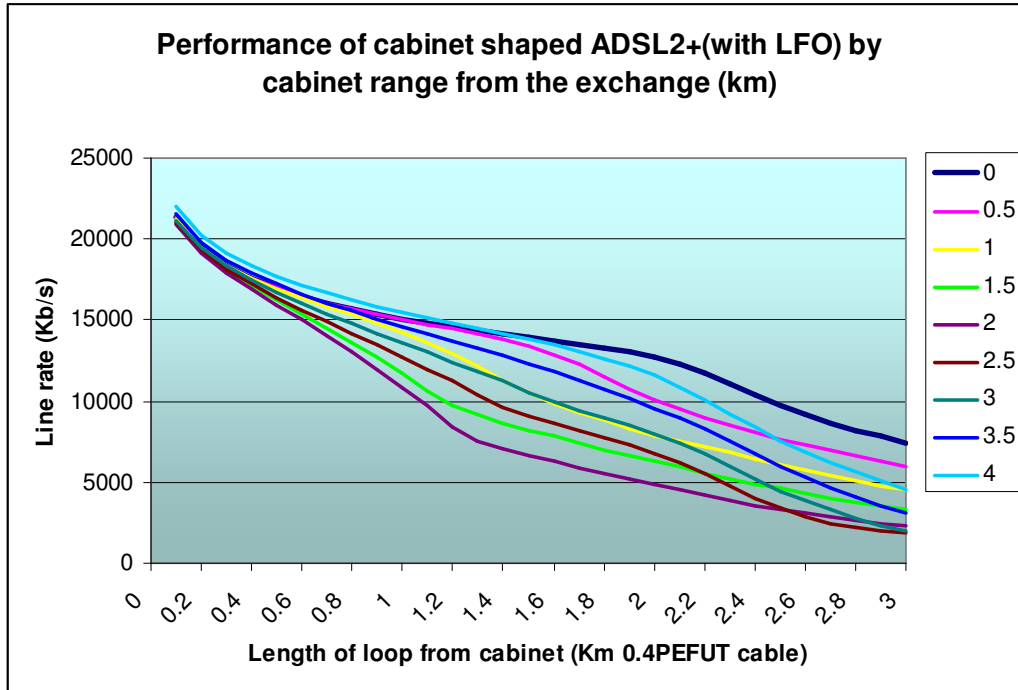
53. For comparison the predicted performance of an exchange launched line is shown for user the same distance (Cabinet distance + 400m) and for a user on a cabinet launched system if no PSD shaping occurs at the cabinet DSLAM.



The effect of varying distance between the exchange and the cabinet for shaped PSD, cabinet launched ADSL2+

54. The following graph shows the calculated reference noise performance of ADSL2+ victims launched from a cabinet for cabinets of varying ranges from the exchange.

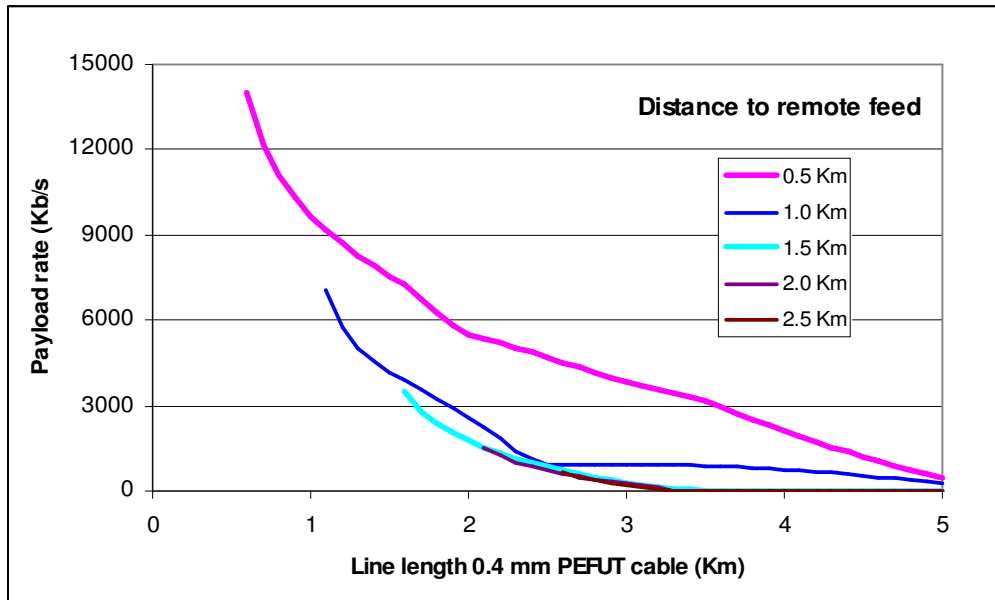
55. The 0 km curve is equivalent to the unshaped cabinet performance.



Exchange launched ADSL2+ for DA in state B (full power from cabinet)

56. The following is the NZ IMP benchmark II curves, which is the reference noise performance of exchange launched ADSL2+ for points beyond the cabinet with cabinets with full power launched from the cabinet.

57. In this graph, distance to remote feed is the distance between the exchange and the cabinet in the dual feed context.



Dual feed and VDSL2

58. VDSL2 utilises additional upstream bands (US1, US2 and US3) above the ADSL2+ band to achieve higher upstream transport capacity.
59. Crosstalk at these higher frequencies is much stronger than in the Upstream 0 (US0) ADSL2+ band.
60. Far end cross talk interference into a cabinet based receiver in the upper Upstream bands can be severe from a VDSL2 modem working back to an exchange located VDSL2 DSLAM.
61. In the UK and Ireland, and in the working draft of the Australian code (not yet agreed), it is the practice to only permit VDSL2 to be launched from cabinets in dual feed distribution areas. In Belgium, dual feed VDSL2 is permitted in some circumstances.
62. Upstream power back off can mitigate this upstream performance impact on sub loop VDSL2 systems in some specific circumstances. For example, in Belgium where 90% of the customers are within 1km of the exchange.

Field Testing

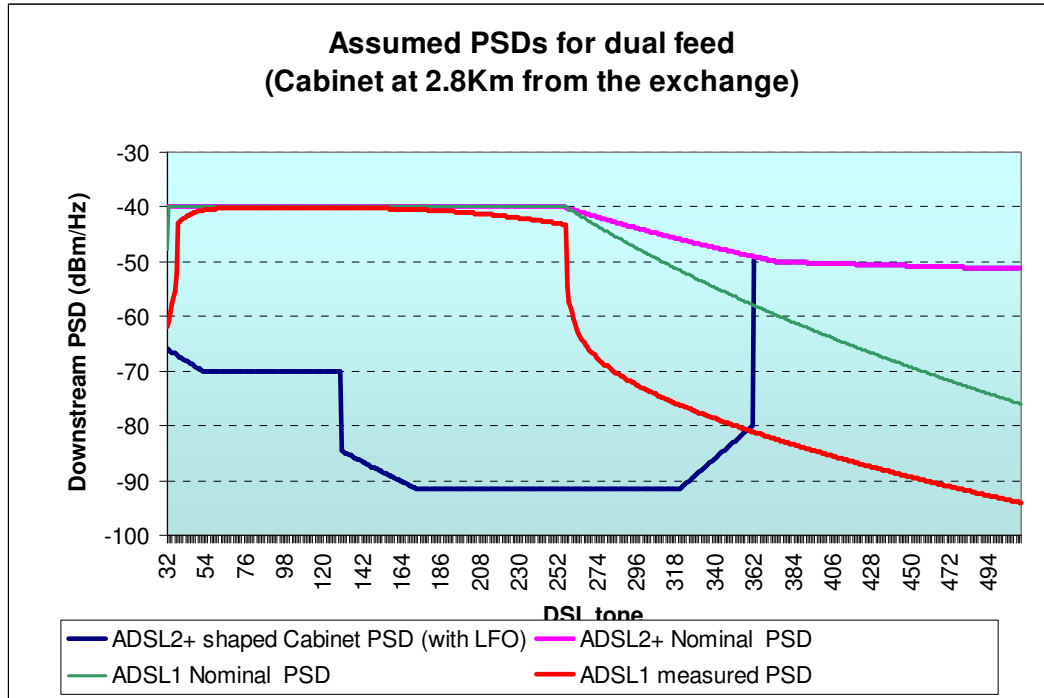
63. Field testing of any proposed shaped PSD profiles may be appropriate to validate the computer models.
64. It is agreed that field testing would only be of any benefit if and when it is agreed that PSD shaping is to be implemented in NZ for dual feed cabinet installations.
65. Because the performance of the copper cable network is variable, for any testing to be statistically significant a large sample of lines (circa several hundred) would need to be used in any test. Meaningful testing therefore cannot be conducted in a laboratory.
66. If testing is to be undertaken, it will need to be conducted on actual lines in use across a statistically significant area(s). IT would involve implementing the proposal in the trial area and monitoring the performance of all in service lines in the area over several weeks.

Summary

67. The introduction of PSD shaping at the cabinet will result in material reduction in line performance of cabinet feed lines over what would be experienced if full power continues to be permitted from the cabinet.
68. The degree of cabinet performance reach reduction is a function of the distance of the cabinet from the exchange and the loop length from the cabinet. However for an “average” cabinet this would be in the range of a 15-50% reduction of otherwise achievable cabinet line rate.
69. If it is decided that cabinet dual feed PSD shaping is to be implemented in NZ, then further optimisation of the various parameters required to define appropriate profiles of NZ would be beneficial.
70. A prerequisite to the above is to define the extent to which ADSL2+ performance from the exchange must be protected.
71. Further study on the problem of ADSL1 would be needed, including the measures that have been adopted in other jurisdictions.
72. Level 2 and 3 Dynamic Spectrum Management is not yet technically ready for commercial industry wide implementation but should be seen as an option for improving service in the future.
73. Field testing of proposed profiles may be beneficial if it is decided that PSD shaping is to be implemented.

Appendix 1: PSD shape used for the simulated examples

74. The following charts show the PSD shape assumed in the examples in this paper for a cabinet located 2.8 Km from the exchange.



Appendix 2: Predicted bit loadings for cabinet launched victims

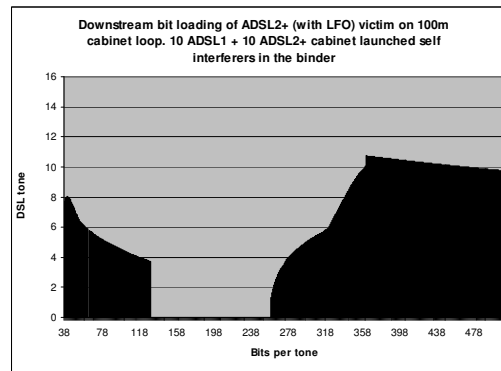
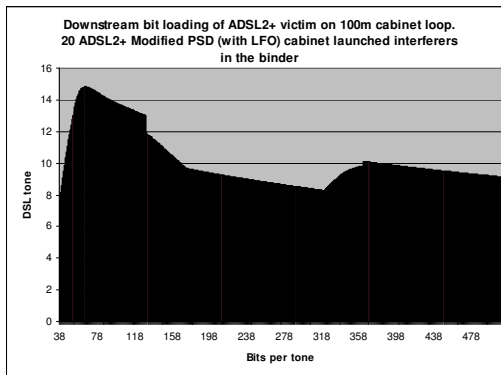
75. The following charts show the modelled bit loading for an ADSL2+ victim on a 100m cabinet loop.

76. Two cases are provided, in both cases the ADSL2+ profile includes LFO proposed by Vodafone,

- a. 10 ADSL1 interferers launched from the cabinet plus 10 ADSL2+ modified PSD interferers
- b. 20 ADSL2+ Modified PSD interferers launched from the cabinet and no ADSL1

77. The simplified cabinet profile is assumed so results are illustrative only

78. The cabinet is located 2.8km from the exchange and NZ 0.4 PEFUT cable is assumed.



Note 1: The roll off of the ADSL1 (measured) PSD above 1.1Mhz is such that significant interference from ADSL1 can still occur into highly attenuated ADSL2+ tones above 1.1Mhz.

Appendix 3: ITU G997.1 modified cabinet downstream profile

79. The following figure shows how the recommended resultant Down Stream Back Off PSD mask is derived in ITU-T 997.1

80. No values for these masks are given in the ITU recommendation.

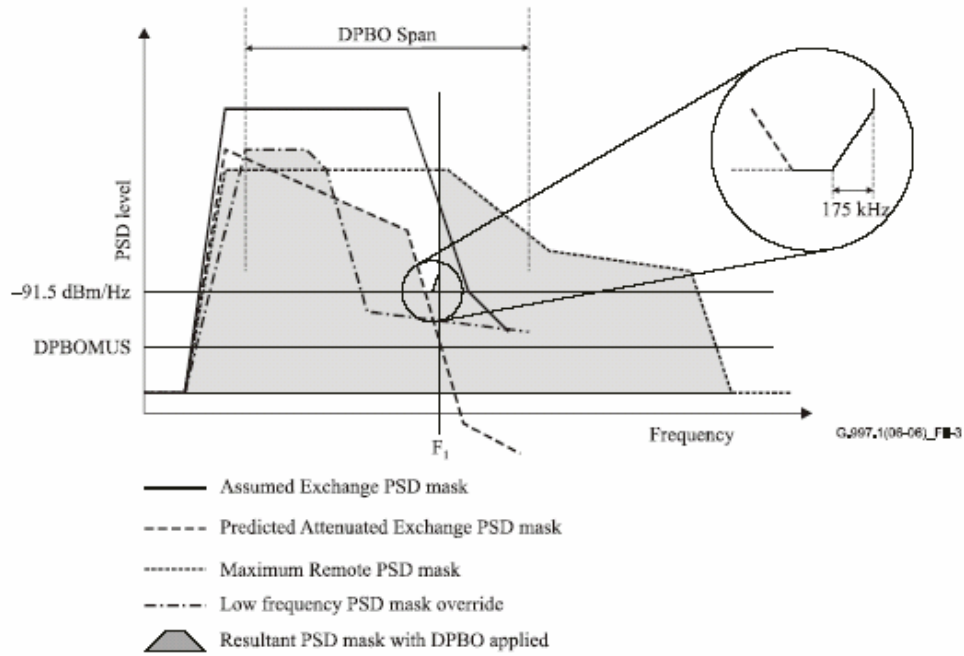


Figure II.3/G.997.1 – Creation of the mask with downstream power back-off