COMMUNICATIONS

ALLIANCE LTD

INDUSTRY CODE

C658:2025

NEXT-GENERATION BROADBAND SYSTEMS
DEPLOYMENT IN CUSTOMER CABLING

PART 2

METHODS FOR DETERMINING COMPLIANCE

C658:2025 Next-Generation Broadband Systems Deployment in Customer Cabling – Part 2 – Methods For Determining Compliance Industry Code

First published as C658:2018
Second edition as C658:2019

Disclaimers

1) Notwithstanding anything contained in this Industry Code:

   a) Communications Alliance disclaims responsibility (including where Communications Alliance or any of its officers, employees, agents or contractors has been negligent) for any direct or indirect loss, damage, claim, or liability any person may incur as a result of any:

      i) reliance on or compliance with this Industry Code;

      ii) inaccuracy or inappropriateness of this Industry Code/Guideline; or

      iii) inconsistency of this Industry Code with any law; and

   b) Communications Alliance disclaims responsibility (including where Communications Alliance or any of its officers, employees, agents or contractors has been negligent) for ensuring compliance by any person with this Industry Code/Guideline.

2) The above disclaimers will not apply to the extent they are inconsistent with any relevant legislation.

Copyright

INTRODUCTORY STATEMENT

This part of the Code should be read in association with Part 1 that describes rules for compliance and Part 3 that describes the defined Deployment Class Systems.

Part 2 provides the full detail of the technical approach to spectrum management that will protect Next-Generation Broadband Systems (NGBS) and Legacy Systems that use Shared Cable Bundles in buildings or campuses from Unacceptable Interference.

The key aspects covered are:

(a) Code compliance calculations;

(b) The process for developing the Code to include newer technologies as they evolve; and

(c) File formats and protocols for information sharing.

Code Compliance Calculations

The technical approach for avoiding Unacceptable Interference into equal or Higher Priority Deployment Class Systems requires operating Systems to limit their transmissions to within the envelopes of Power Spectral Density (PSD) defined by PSD Masks.

PSD Masks apply at certain reference points or specific locations on the cable topology. When Digital Subscriber Loop Access Multiplexers (DSLAMs) are not co-located, this part of the Code defines referral of the PSD Masks to other locations based on the type and attenuation of the cable separating the DSLAMs.

If a System is a Vectored (crosstalk cancelling) Deployment Class System, additional margins are required to be applied to the relevant PSD Masks in order to protect the effectiveness of vectoring.

In order to simplify the application of this Code, certain combinations of Deployment Class Systems and System configurations are deemed to be permitted to coexist in a Shared Cable Bundle. This part of the Code defines processes to align System parameters, including Upstream Power Back Off descriptors, to facilitate such 'deemed compliance' with the Code.

To facilitate spectral compatibility with a Legacy System or a Deployment Class System that uses spectrum below 2.208MHz deployed at a higher network location, this part of the Code describes Downstream Power Back Off shapers that are required to be applied by Systems sharing a Shared Cable Bundle.

Process to evolve the Code

Additional Next-Generation Broadband technologies may emerge in the future. This part of the Code describes the process for developing additional Deployment Class System descriptions that may be included in future revisions of this Code.

TABLE OF CONTENTS

1 GENERAL

1.1 Purposes of Part 2 of the Code

Definition of the technical processes for determining compliance with this Code

1.1.1 Part 1 of this Code requires Systems not to emit Unacceptable Excess Power and Systems not to cause Unacceptable Interference to other Higher Priority Deployment Class Systems or to Legacy Systems in a Shared Cable Bundle. Part 2 of this Code defines the detailed technical methods and calculations required to demonstrate those requirements are met.

> *NOTE: Systems that are not defined in this Code as Deployment Class or Legacy Systems or systems that are not operated in accordance with the Deployment Class conditions defined in this Code are Non-Deployment Class Systems. The Code permits operation of Non-Deployment Class Systems in Shared Cable Bundles providing those Systems do not emit Unacceptable Excess Power and do not cause Unacceptable Interference to another Deployment Class System.*

1.1.2 Many of the technical requirements of this Code are ascertained by the comparison of various PSD Masks. Part 2 of this Code outlines the process for deriving and comparing PSD Masks. The varieties of PSD Mask are introduced in Section 1.2.

1.1.3 PSD Masks apply at specific positions in the cable topology. When comparing two PSD Masks, both PSD Masks need to be referred to the same position in the cable topology. If a particular PSD Mask needs to be compared against another PSD Mask that is defined at a different position in the cable topology, this part of the Code explains how PSD Masks are referred in order to validly compare them. The concept of referral is introduced in Section 1.3.

1.1.4 If the PSD emitted by a System at a particular frequency exceeds that PSD Mask when referred to the position in the cable topology at which a PSD Mask applies, the System does not comply with the applicable requirement at that frequency.

Definition of System information to be Notified to facilitate harmonious System coexistence

1.1.5 System Providers desiring to benefit from the protections offered by the Code must notify other System Providers about certain operational and configuration aspects of their System. The notification process also establishes System priority and allows all Providers to determine whether their configurations can harmoniously coexist. This part of the Code sets out the scope and format of Notified information and defines how to correctly interpret Notified information provided by other Providers.

NOTE: In order for this Code to function efficiently to achieve the harmonious coexistence of NGBS, System notifications and changes of notifications must be timely and accurate. Part 1 of this Code requires notifications to be timely and accurate, and requires notification errors to be promptly retracted or corrected. System Providers that publish inaccurate notifications or that do not promptly correct errors in published notifications or that do not respond in a timely manner to the notification and Sharing Resolution Processes are not operating their Systems in accordance with this Code.

1.1.6   The notification requirements are explained in Section 12.

Definition of the process and information required to propose additional Deployment Class Systems

1.1.7   From time to time, as technologies and Deployments evolve, parties may seek to introduce new Deployment Class System definitions into the Code in order that their Deployments may benefit from the protections offered by the Code. This part of the Code outlines the scope and detail of the information required to support proposals for new Deployment Class Systems.

1.2   Types of PSD Mask

1.2.1   Several different kinds of PSD Mask are referred to in this Code. The kinds of PSD Mask include:

(a)   the General Excess PSD Mask, the purpose of which is to define the upper envelope of permissible PSD applicable to every System, to protect every other System from Unacceptable Excess Power.

NOTES:

1. The General Excess PSD Mask applies to every System at the System's External Interface Port.

2. This means that the General Excess PSD Mask applies to DSLAMs and applies to CE.

(b)   Limit PSD Masks, the purpose of which is to define the upper envelope of permissible PSD in a particular situation.

NOTE: Each Deployment Class System definition includes Limit PSD Masks that apply to that particular Deployment Class System at its External Interface Ports.

(c)   Template PSD Masks, the purpose of which is to define the envelope of a System's nominal transmit PSD.

NOTES:

1. This Code requires verification of Non-Deployment Class System compatibility through a process of specified calculations. The

calculations involve Limit and Template PSD Masks for each System.

2. Each Deployment Class System definition includes an explanation of how to derive the Template PSD Masks from its Limit PSD Masks. These derived PSD Masks are then applied to proposed Non-Deployment Class System Deployments to verify that the proposed Deployment complies with the Code.

3. Providers of Non-Deployment Class Systems should derive Limit and Template PSD Masks for their Systems either from the standards that define those Systems or from the System's technical specifications.

(d) Coexistence Masks, which limit the PSD of a Non-Deployment Class System in order to prevent it from causing Unacceptable Interference to the associated Deployment Class System.

NOTES:

1. Each Deployment Class System definition includes either Adjusted (if Vectored) or Unadjusted (if non-Vectored) Coexistence Masks and a specific location or locations at which each Coexistence Mask applies. The Coexistence Mask defines the envelope of PSD that must be satisfied by a Non-Deployment Class System when that envelope of PSD has been referred to the defined location at which the Coexistence Mask applies. Different Coexistence Masks apply in the upstream and Downstream directions.

2. Systems which apply Upstream Power Back Off determine transmit PSD according to their specific position in the deployed cable topology. This causes CE PSD to be position dependent. To accommodate the behaviour of Upstream Power Back Off when determining spectral compatibility, each Deployment Class System definition indicates whether the Upstream Coexistence Mask requires multiple calculations for applying the Coexistence Mask at more than one hypothetical CE location.

*3. **Warning:** Configuring Coexistence Mask PSD coordinates directly into a Non-Deployment Class System without appropriate referral of its transmit PSD does not ensure compliance with the Code, and will frequently cause Unacceptable Interference.*

4. For Time Division Duplex (TDD) Systems, Coexistence Masks are considered to apply at all times, irrespective of the actual burst timing. In determining compliance of a TDD System, the PSD is the average during the "on" part of the TDD duty cycle in that direction.

(e) Legacy Coexistence Masks, which limit the PSD of all Systems at frequencies below 2.208 MHz, in order to prevent Unacceptable Interference in that band to the associated Legacy System or VDSL2 Deployment Class System sharing

the Shared Cable Bundle if at least one other System is positioned at a Higher NRP.

> *NOTES:*
>
> *1. The Downstream Legacy Coexistence Mask applies at the DSLAM of the Legacy System or Deployment Class System being protected. A System's Downstream PSD in Spectrum That Overlaps at frequencies below 2.208 MHz must be referred to that location in order to be compared with the Downstream Legacy Coexistence Mask.*
>
> *2. The Upstream Legacy Coexistence Mask applies at the System's CE and does not require referral of the System PSD.*

(f)   DPBO PSD Masks, the purpose of which is to enable deemed compliance with the Downstream Legacy Coexistence Mask.

> *NOTES:*
>
> *1. If the System at a Higher NRP is a Legacy System, the Spectrum That Overlaps includes only those frequencies in the range from 25 kHz to 2.208 MHz.*
>
> *2. An assessment is required to choose the most appropriate DPBO PSD Mask when there are non-co-located Systems. This process is outlined in section 6.2.3.4.*

1.3   PSD Mask Adjustment and Referral

1.3.1   Coexistence Masks for Deployment Class Systems are adjusted to a lower PSD level by an amount equal to the assumed Maximum Vectoring Gain (expressed in dB) in those bands in which Vectoring is applied. These are called Adjusted PSDs or Adjusted PSD Masks. Coexistence Masks for non-Vectored Systems are therefore not adjusted because Vectoring is not applied in any bands.

1.3.2   Whenever Systems are not physically co-located but share segments of cable or Shared Cable Bundles, System PSD Masks may require referral to compensate for the attenuation of cables serving those Systems. These are called Referred PSD Masks.

1.4   Avoiding use of certain spectrum

In order to comply with an applicable PSD Mask so as to avoid causing Unacceptable Interference or to avoid emitting Unacceptable Excess Power, Providers must:

(a)   refrain from using the parts of the spectrum in which their System's signals would exceed the applicable PSD Mask, or

(b)   apply spectral shaping at either the DSLAM or CE or both in those parts of the spectrum for which the System's signals would exceed the applicable PSD Mask.

1.5   Efficient Tie Cable requirements

1.5.1   A Provider must where required by this Code permit a System's Tie Cable to be extended in length or to be replaced with a higher attenuation Tie Cable in order to facilitate sharing in accordance with the Sharing Resolution Process, provided that the additional Tie Cable length or attenuation is no more than efficiently required to enable a viable sharing outcome.

> *NOTE: It is expected that the cost of extending the length or increasing the attenuation of an already efficient Tie Cable in order to facilitate sharing in accordance with the Sharing Resolution Process will be borne by the party Deploying the Subsequent System.*

1.5.2   A Provider must where required by this code remove unnecessary length from its System's Tie Cable in order to achieve an efficient Tie Cable that facilitates sharing in accordance with the Sharing Resolution Process, including by rerouting a Tie Cable which was not deployed along the most efficient available cable pathway.

> *NOTES:*
>
> *1. Paragraph 1.5.2 is intended to prevent an inappropriately routed Tie Cable from triggering forced spectrum splitting coexistence options when those options could otherwise have been avoided by originally deploying a shorter Tie Cable.*
>
> *2. It is expected that the cost of rerouting an inefficiently routed Tie Cable in order to facilitate sharing in accordance with the Sharing Resolution Process will be borne by the party responsible for the inefficient Tie Cable.*

1.5.3   A Provider may be required to permit a Tie Cable to be reduced in attenuation in order to achieve an efficient Tie Cable that facilitates sharing in accordance with the Sharing Resolution Process.

> *NOTE: It is expected that the cost of replacing a Tie Cable constructed from higher loss material with a Tie Cable constructed from lower loss material in order to facilitate sharing in accordance with the Sharing Resolution Process will be borne by the party Deploying the Subsequent System.*

2 PERFORMANCE REQUIREMENTS AS A BASIS FOR DEPLOYMENT RULES

2.1 Past Policy Context (Informative)

2.1.1 The Australian Government Statement of Expectations for nbn from 2016 set out two specific performance requirements for NGBS delivered by nbn, stating that within the national footprint of services:

(a) 100% of all premises should be provided with peak wholesale download data rate of at least 25 Mbit/s; and

(b) 90% of fixed line premises should be provided with at least 50 Mbit/s as soon as possible.

In this Code, 'wholesale download data rate' is interpreted to mean 'Layer 2 Rate Downstream'.

> *NOTES:*
>
> *1. In July 2020, the Statutory Infrastructure Provider (**SIP**) regime in Part 19 of the Telecommunications Act 1997 commenced. nbn is the default SIP for Australia, and other providers may become the SIP in specific geographic areas (typically where they contract to serve a new development). SIPs are required to connect premises to their telecommunications networks and supply wholesale broadband services to retail providers so they can supply services to end-users, with the legislation specifying peak speeds of at least 25/5 Mbit/s. The SIP legislation contains additional targets for nbn, including that nbn should take all reasonable steps to ensure at least 90% of premises in the fixed line footprint have access to at least 50/10 Mbit/s.*
>
> *2. The Statement of Expectations for NBN Co from December 2022 references nbn's role as the default SIP.*
>
> *In addition, it contains more information about upgrading the network to access "up to" a nominated data rate. For example:*
> *(a) Upgrading the reach of fibre so 90% of premises in the fixed line footprint have access to peak wholesale download speeds of up to 1 Gbit/s.*
> *(b) Upgrading the fixed wireless network for access to wholesale download speeds of up to 100 Mbit/s, and typical wholesale busy hour speeds of at least 50 Mbit/s.*
> *(c) Ensuring at least 80% of regional and remote premises have access to wholesale download speeds of at least 100 Mbit/s by 2025.*

2.1.2 A third requirement, that Infrastructure competition is to be facilitated where viable without unduly impacting service performance, was set out in the Government policy paper *Telecommunications Regulatory and Structural Reform* which included:

(a) The policy principle that "*Regulation should allow competition at both the retail and wholesale/infrastructure levels.*"; and

(b) A response to the recommendations by the Vertigan panel in the *Independent cost-benefit analysis of broadband and review of regulation,* where the panel expressed the view that:
"*In principle, end-users should not be prevented from having a choice of service providers and should not be forced to change service provider (other than in circumstances where a service provider is no longer willing to provide services*".

2.1.3 In cases where more than one Provider shares a Shared Cable Bundle, this code implements ensures that at least one Provider achieves 25 Mbit/s Layer 2 Rate Downstream for all services fed through that Shared Cable Bundle. The facilitation of infrastructure competition where viable without unduly impacting service performance (referred to in 2.1.2) in a specific Shared Cable Bundle is contingent upon this.

2.1.4 Because it is a statistical statement about an aggregate national outcome, ascertainment of the proportion of premises having access to specified speeds cannot apply individually to any particular area, building or Campus.

In recognition of the typical cable attenuation range difference between FTTN and FTTB Deployments, the higher 50 Mbit/s requirement is reflected in this Code in relation to certain building Deployments. The expectation is that building DSLAMs serving end user premises within the same building will achieve 50 Mbit/s Layer 2 Rate Downstream in all permitted sharing situations. For clarity, the 50 Mbit/s requirement should not be applied to a DSLAM serving multiple buildings or FTTB Deployments in a Campus because in these situations, the typical cable attenuation range is greater.

2.1.5 Vectoring (crosstalk cancellation) is an International Standards based capability that enables significant layer 2 rate improvement compared with non-Vectored operation. For the purpose of determining whether a System is able to achieve Full Coverage and hence a Higher Priority status under this Code, the actual operating mode (Vectored or non-Vectored) of the System must be used in making that assessment.

In assessing the viability of a forced change in Deployment Class for a Prior System under the rules of Part 1 Section 6.3, the capability of the changed Deployment Class to achieve Full Coverage must be assessed assuming the Vectored or non-Vectored operational capability of the forced change in Deployment Class.

2.1.6 For the purpose of assessing Full Coverage in this Code, all elements of the cable infrastructure between a DSLAM and CE are assumed to be installed in accordance with G649, to be in

good working order, and free of impairments. Impairments include bridged taps, degraded electrical joints or contacts, breached moisture barriers, incorrectly installed filters or devices, untwisted pairs, split pairs, and other problems or faults in the cable infrastructure.

> *NOTE: Impaired cables may lead to reduced data rates. If reduced rates are a consideration, impaired cables should be serviced by the cable owner to eliminate the impairments in order for Systems Deployed over those cables to perform in accordance with the expected rates outlined in this Code.*

2.1.7   For the purpose of assessing Full Coverage in this Code, sources of noise or interference include only crosstalk from 8 like Deployment Class System and background noise.

> *NOTES:*
>
> *1. The cross section of a typical Australian Distribution Cable is made up of sub-units of ten pairs each. The assumption of 8 like Deployment Class Systems is intended to imply a cable utilisation of 90 percent of that sub-unit, namely the one service being interfered with, and eight interferers.*
>
> *2. Artificial noise sources including radio transmitters and non-sinusoidal electrical loads are not considered in the assumed level of background noise because well balanced twisted pair cable effectively rejects such noise sources.*

2.2   Calculation of Full Coverage Deployment Attenuation Limits for Deployment Classes

2.2.1   Full Coverage Deployment attenuation limits, at which each Deployment Class achieves either 25 Mbit/s or 50 Mbit/s Layer 2 Rate Downstream with 99% confidence (that is on the cable pair at the 99th percentile of crosstalk interference), are determined using the assumptions, methods and tools described in Section 15. These ranges are calculated for both Vectored and non-Vectored implementations of each Deployment Class.

3 DEFINITION OF NEW DEPLOYMENT CLASS SYSTEMS

3.1 Basis in International Standard

3.1.1 Deployment Class Systems must be based on an International Standard System.

3.1.2 An International Standard is a standard issued by a standards body recognised by Standards Australia, or a recommendation issued by the International Telecommunication Union Telecommunication Standardization Sector (ITU-T).

3.2 PSD Masks

3.2.1 The first step in the process of defining a new Deployment Class System is to identify the Downstream and Upstream Limit PSD Masks and Template PSD Masks.

    3.2.1.1 If the prospective Deployment Class System is to be based upon a variation of an existing Deployment Class System, the Limit and Template PSD Masks for the prospective Deployment Class System will generally be closely related to the existing Deployment Class System PSD Masks.

    3.2.1.2 If the prospective Deployment Class System is to be based on a new technology for which no previous Deployment Class Systems have been defined, the Limit PSD Masks and Template PSD Masks will generally be specified in the International Standard that defines the new technology.

    3.2.1.3 If Limit PSD Masks and Template PSD Masks are not defined in the applicable International Standard, or are modifications of the International Standard PSD Masks, they should be calculated based upon the electrical specifications provided in the International Standard, and the calculations should be presented to a panel of Communications Alliance experts for peer review and approval.

3.2.2 The second step in the process of defining a new Deployment Class System is to incorporate the Limit PSD Mask for the proposed Deployment Class System into the General Excess PSD Mask.

    3.2.2.1 The General Excess PSD Mask is the envelope of all Deployment Class System Limit PSD and Legacy System PSD Masks, as described in Section 4.

    3.2.2.2 When a new Deployment Class System is introduced, the General Excess PSD Mask may need to be updated to accommodate the new Deployment Class System's spectral usage.

- 13 -

3.2.2.3 If the Limit PSD Mask for the proposed Deployment Class System is entirely encapsulated under the existing General Excess PSD Mask, then no changes are required to the existing General Excess PSD Mask. Otherwise, a new General Excess PSD Mask should be defined encapsulating the envelope of the proposed Deployment Class System in addition to the envelope of all existing Deployment Class Systems.

3.2.3 The third step in the process of defining a new Deployment Class System is to derive Coexistence Masks from the Deployment Class System Limit PSD Masks.

3.2.3.1 Coexistence Masks are designed to prevent interference from Lower Priority Systems being any worse than what is considered acceptable for the particular Deployment Class System. A simple guideline is that a Coexistence Mask is defined as a level at which the crosstalk from the proposed System would be no worse than crosstalk in Shared Cable Bundles carrying the Deployment Class System services, or in the case of a Vectored System the residual crosstalk after Vectoring cancellation of the Deployment Class System crosstalk.

3.2.3.2 For non-Vectored Deployment Class Systems, or non-Vectored bands used by Vectored Deployment Class Systems, the Coexistence Mask will match the Deployment Class System's nominal or Template PSD within the Deployment Class System's bands that carry Coded Data.

3.2.3.3 For Vectored bands used by Vectored Deployment Class Systems, the Coexistence Mask will be at a level below the Deployment Class System Template PSD, offset by an amount equal to the Deployment Class System's Maximum Vectoring Gain. For example, for VDSL2 Systems the Maximum Vectoring Gain is 25dB as specified in Table 15, so the Coexistence Mask is offset from the Deployment Class System Template PSD Mask by -25dB in Vectored bands.

3.2.3.4 Outside the band between the lowest and highest frequencies that may be used to carry Coded Data in either direction by either:

(a) a full spectrum Deployment Class System, or

(b) the union of the spectrum of a complementary pair of split spectrum Deployment Class Systems;

the Coexistence Mask is undefined, although the General Excess PSD Mask remains effective in constraining a System's PSD.

NOTE: It is recognised that the Deployment Class System receiver will capture a small proportion of the signals in

> *the nearest few kHz of adjacent frequency bands. However, the requirement for the System to meet the Coexistence Mask at the band edge, and the practical need to design Systems that limit the slope of the PSD, should ensure minimal impact on the Deployment Class System.*

3.2.4 The fourth step in the process of defining a new Deployment Class System is to specify the spectral usage for the proposed Deployment Class System.

    3.2.4.1 For every Deployment Class, it is necessary to specify the Operating Frequency Range and for frequency domain duplex technologies to identify Upstream and Downstream bands.

    3.2.4.2 The Upstream and Downstream bands correspond to the spectrum in each transmission direction in which the prospective Deployment Class System is permitted to carry Coded Data.

    3.2.4.3 For TDD systems such as G.fast, the spectral usage is the same for each direction of transmission.

3.2.5 Additional steps may be required when defining a new Deployment Class System such as indicated in 3.4.1(b) and 3.4.2.

3.3 Line codes and Deployment limits

3.3.1 The ability of a System to meet the Government policy objectives depends on many factors including the intrinsic technical capabilities of the line coding scheme. The line coding scheme used by each Deployment Class System must therefore be specified.

3.3.2 For each Deployment Class, it is necessary to specify any Deployment limits or constraints required for the System to operate in accordance with its standard, and in harmony with other Deployment Class Systems in a Shared Cable Bundle.

3.4 Determination of suitability as a Deployment Class System

3.4.1 When defining a new Deployment Class, the Code may:

(a) make performance compromises consistent with the Code's access speed targets and to allow coexistence with an existing Deployment Class; or

(b) establish additional Deployment Classes (such as variations of the proposed and original Deployment Classes) to facilitate coexistence.

3.4.2   If technically feasible, each prospective Deployment Class technology should admit one or more deemed coexistent Deployment Classes.

> *NOTES:*
>
> *1. These alternatives are required to permit the new Deployment Class System to coexist with at least one other Deployment Class System technology, if technically feasible.*
>
> *2. At least one of the coexisting Deployment Classes should be capable of satisfying the Government policy.*

3.4.3   In special cases and subject to 3.4.4, a Deployment Class may be defined with no deemed coexistence solutions, provided it can be shown to provide superior rates and/or coverage than present Deployment Class System options for a specific class of customer premises environments.

3.4.4   In order to enable sharing with a Subsequent System under the rules of Part 1 Section 6.3, a System may at a later stage need to vacate part of its spectrum, and to facilitate sharing a new Deployment Class with vacated spectrum may be defined.

> *NOTES:*
>
> *1. For example, in the future, a G.fast Deployment Class may be defined over the full spectrum from 2 MHz to 212 MHz with no coexisting Deployment Class Systems, with a Deployment condition that Systems of this proposed Deployment Class are capable of Full Coverage across the accessible Shared Cable Bundle footprint.*
>
> *2. If such a G.fast Deployment Class System is defined, additional coexisting G.fast Deployment Classes are also expected to be defined to enable coexistence with VDSL2. The additional coexisting G.fast Deployment Classes would be expected to be constrained to only a part (e.g. only above 20 MHz) of the spectral range from 2 MHz to 212 MHz in order to facilitate such coexistence.*
>
> *3. In accordance with the Government's competition policy, a G.fast System initially Deployed using such a full-spectrum Deployment Class would be expected to vacate part of its spectrum and move to a coexisting G.fast Deployment Class if technically feasible and consistent with this Code, in order to enable deemed sharing with a VDSL2 Deployment Class System.*

3.5 Additional detail about Coexistence Masks

3.5.1 The interference from a Non-Deployment Class System is controlled by requiring that the Non-Deployment Class System's transmitted PSD in each direction does not exceed the Coexistence Mask of the Deployment Class System in that direction. This approach simplifies compliance calculations for Non-Deployment Class Systems, as there is no requirement to directly calculate all combinations of crosstalk and bit rate.

> *NOTE: In the Upstream direction, different CE may be located at different attenuations from their host DSLAM. To determine compatibility of the proposed System when UPBO is in operation for the Deployment Class System, a separate Upstream Coexistence Mask must be calculated (at the time of comparing the Non-Deployment Class System against the PSD Mask) for each potential CE location relative to the Deployment Class System DSLAM. The requirement to have a distinct Upstream Coexistence Mask for each possible CE location is intended to ensure alignment of the highest permitted proposed System Upstream signals with what would have been transmitted from the same location by a Deployment Class System under its own UPBO rules. The Downstream Coexistence Mask is defined at the External Interface Port of the DSLAM for the Deployment Class System.*

3.5.2 The Upstream Coexistence Mask is defined at the External Interface Port of the CE for the Deployment Class System.

3.5.3 When applying a Downstream Coexistence Mask to determine compliance of a Non-Deployment Class System, refer the PSD of the Non-Deployment Class System to the location of the External Interface Port of the Deployment Class System against which it is being compared.

3.5.4 If a Deployment Class System is deemed to be able to coexist with another Deployment Class System (based on Table 2 or 3 of Part 1), it is not required to satisfy the Coexistence Mask for that other Deployment Class System.

> *NOTE: Deemed coexistence by the Deployment Class System has already been based on a full calculation of rates vs attenuation for that other Deployment Class System.*

4   DEFINITION OF THE GENERAL EXCESS PSD MASK

4.1   Determining the General Excess PSD Mask

4.1.1   The General Excess PSD Mask is defined to be the envelope of all Deployment Class System Limit PSD Masks, all limit (Group B) PSD Masks defined in C559 Part 3, and the Limit PSD Masks for all versions of G.fast which this Code permits as a Non-Deployment Class System but cannot yet include as a Deployment Class System because of the need to perform further work to resolve the rate/coverage issues.

4.1.2   The General Excess PSD Mask (GEM) is derived from the break points in Table 1 by interpolating adjacent coordinates between the lower coordinate frequency (f_{lower}) and the upper coordinate frequency (f_{upper}).

4.1.3   Logarithmic interpolation must be used when the lower coordinate frequency is less than 3.575 MHz, as described in Equation 1, and linear interpolation must be used when the lower coordinate frequency exceeds 3.575 MHz, as described in Equation 2.

EQUATION 1
**Logarithmic interpolation formulae for use with
lower coordinate frequency less than 3.575 MHz**

Formulae	Notes
$$slope = \left(\frac{GEM(f_{upper}) - GEM(f_{lower})}{\log_{10} f_{upper} - \log_{10} f_{lower}} \right)$$ $$GEM(f) = GEM(f_{lower}) + slope \times (\log_{10} f - \log_{10} f_{lower})$$	Used for log interpolation

4.1.4   Linear interpolation must be used when the lower coordinate frequency exceeds 3.575 MHz, as described in Equation 2.

EQUATION 2
**Linear interpolation formulae for use with
lower coordinate frequency greater than 3.575 MHz**

Formulae	Notes
$$slope = \left(\frac{GEM(f_{upper}) - GEM(f_{lower})}{f_{upper} - f_{lower}} \right)$$ $$GEM(f) = GEM(f_{lower}) + slope \times (f - f_{lower})$$	Used for linear interpolation

TABLE 1
General Excess PSD Mask coordinates

Frequency (kHz)	GEM(f) (dBm/Hz)	Frequency (kHz)	GEM(f) (dBm/Hz)	Frequency (kHz)	GEM(f) (dBm/Hz)
0.01	-40	556.3125	-37.4	17664	-56.5
4.3125	-32.5	1104	-37.5	18875	-65
21.5625	-32.5	1622	-47.5	20000	-65
25.875	-32.65	2208	-48.8	30000	-65
56.0625	-36.13	2208	-49	30000	-73
60.375	-36.4	3750	-52.2	106000	-76
103.5	-36.4	5200	-53.7	212000	-79
107.8125	-38	8500	-55.8	232000	-110
228.5625	-38	10000	-56.5	236000	-112.5
280.3125	-37	12000	-56.5		
552	-37	12000	-56.5		
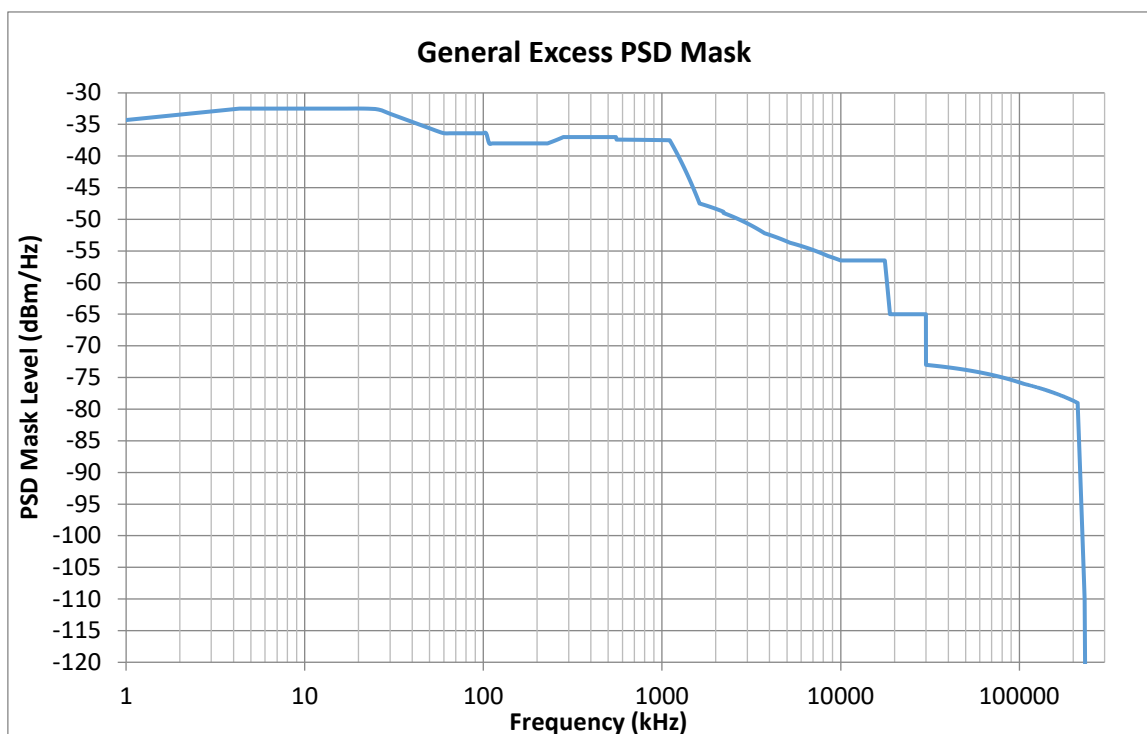
FIGURE 1
The General Excess PSD Mask

5   ASSESSMENT OF UNACCEPTABLE EXCESS POWER

5.1   Deemed compliance for Deployment Class Systems

5.1.1   Because the General Excess PSD Mask is derived from all of the Deployment Class Systems and G.fast, all Deployment Class Systems and G.fast Systems that transmit within their defined Limit PSD Masks and within the total power limit specified in the relevant ITU-T recommendation are deemed not to cause Unacceptable Excess Power.

5.2   Compliance of Non-Deployment Class Systems

5.2.1   Non-Deployment Class Systems are assessed for Unacceptable Excess Power based on the Limit or maximum PSD that the System can transmit from its DSLAM or CE locations.

> NOTES:
>
> 1. There is no requirement to refer Unacceptable Excess Power PSD based on location or any other factor. Unacceptable Excess Power should not be referred.
>
> 2. The Limit PSD Mask $L_{PSD}(f)$ for a Non-Deployment Class System may be obtained from a relevant standard.

5.2.2   The burden of proof for demonstrating compliance of a Non-Deployment Class System with the requirements of this Code rests with the Non-Deployment Class System Provider.

5.2.3   As required by Part 1, upon request from a stakeholder or Provider of a Higher Priority System sharing a Shared Cable Bundle with a Non-Deployment Class System, the Non-Deployment Class System Provider must either (a) promptly make available a full technical report that demonstrates compliance of that Non-Deployment Class System with the relevant PSD Masks, or (b) cease operation of the Non-Deployment Class System.

> NOTES:
>
> 1. Reports prepared by a third party such as the equipment vendor or a NATA or NATA MRA partner accredited laboratory are preferred.
>
> 2. Reports which do not clearly describe the conditions and configurations tested, the measurement methods and measurements, any relevant calculation methods and the results thus obtained, are not required to be accepted.
>
> 3. Where equipment has been tested and shown to comply with an International Standard, a readout of the profile settings and values from the DSLAM and Customer Equipment can be adequate to demonstrate compliance, where those parameters match the code requirements.

> *4. Providing this information is necessary to avoid delay in facilitating the harmonious coexistence of Systems.*

5.3 Identifying Unacceptable Excess Power

5.3.1   A System emits Unacceptable Excess Power in a particular transmission direction if its Limit PSD Mask for that transmission direction exceeds the General Excess PSD Mask at any frequency.

5.3.2   A System emits Unacceptable Excess Power in a particular transmission direction if the actual envelope of the PSD emitted by that System for that transmission direction, measured at the External Interface Port of the System, exceeds the General Excess PSD Mask at any frequency, when measured with a detector with bandwidth of 10 kHz.

> *NOTE: The distinction between 5.3.1 and 5.3.2 is that all Systems must both be specified to operate within the bounds of the Unacceptable Excess Power Mask, as well as to actually operate within the bounds of the Unacceptable Excess Power Mask.*

6 METHOD FOR ASSESSMENT OF UNACCEPTABLE INTERFERENCE TO LEGACY SYSTEMS AND VDSL2 SYSTEMS BELOW 2.208 MHZ

6.1 Protection of Legacy Systems using Legacy Coexistence Masks below 2.208 MHz

6.1.1 The purpose of Legacy Coexistence Masks is to define the envelope of Downstream and Upstream PSD necessary to protect Legacy ADSL Systems and the corresponding bands of VDSL2 Deployment Class System from Unacceptable Interference caused by Systems Deployed to the same Shared Cable Bundle.

> *NOTES:*
>
> *1. Legacy Coexistence Masks should not be confused with Coexistence Masks, whose purpose is to protect Deployment Class Systems from Interference caused by other Systems in all frequency bands.*
>
> *2. Below 2.208 MHz, both Coexistence Mask types apply.*

6.1.2 When sharing a Shared Cable Bundle with a Legacy ADSL System or a Deployment Class System fed from a Higher NRP, a proposed System's Downstream PSD may comply with a Downstream Legacy Coexistence Mask below 2.208 MHz in order to avoid Unacceptable Interference to that Legacy ADSL System or Deployment Class System fed from a Higher NRP according to the requirements of C559 Deployment State A.

6.1.3 That Downstream Legacy Coexistence Mask is defined at the External Interface Port of the DSLAM of the Legacy ADSL System or Deployment Class System to be protected, and is generally set to be the same as the Downstream Limit PSD Mask of the Legacy ADSL System.

> *NOTE: The transmit PSD Mask of the System would need to be referred to the Legacy ADSL or Deployment Class System DSLAM in order to be compared with the Downstream Legacy Coexistence Mask.*

6.1.4 In order to avoid causing Unacceptable Interference to a Legacy ADSL System, a System's Upstream PSD at frequencies below 2.208 MHz should not exceed the Upstream Limit Mask for the Legacy System or Deployment Class System.

> *NOTES:*
>
> *1. This means that the Upstream Limit Mask for the Legacy System or Deployment Class System is used as the Upstream Legacy Coexistence Mask, below 2.208 MHz. Specific Legacy Upstream Coexistence Masks are not explicitly defined in this Code.*
>
> *2. There is no need to refer the Upstream PSD as the Upstream Legacy Coexistence Mask always applies at the External*

> *Interface Port of the CE of the System being assessed for compliance.*

6.1.5   It is anticipated that Legacy Systems and technologies will be retired in the coming years. The protection of Legacy ADSL Systems using Legacy Coexistence Masks below 2.208 MHz outlined in this section will continue to apply to all Systems even after the retirement of all Legacy Systems, but only to protect Deployment Class Systems operating from Higher NRPs.

> *NOTE: This means that NGBS will continue to be required to shape spectrum below 2.208 MHz whenever there are other NGBS at Higher NRPs using that spectrum and sharing the Shared Cable Bundle.*

6.2   Deemed Protection of Legacy Systems using DPBO PSD Masks below 2.208 MHz

6.2.1   Because the rules of C559 ensure the necessary protection of Legacy ADSL (Basis) Systems in Deployment State A from Unacceptable Interference, any Deployment in Customer Cabling that would have met the deployment rules of C559, if Customer Cabling had been included in the C559 scope, is deemed to comply with the requirement not to cause Unacceptable Interference to a Legacy System.

6.2.2   One way to comply with C559 rules and hence avoid Unacceptable Interference to a Legacy System is to use one of the DPBO PSD Masks defined in this Code. Deemed compliance using DPBO PSD Masks ensures protection from Unacceptable Interference for Legacy ADSL Systems such as ADSL or ADSL2+ and the corresponding bands of VDSL2 Deployment Class System Deployed to the same cable bundle.

6.2.3   **No Shaped System at a Higher NRP**

6.2.3.1   Wherever a System is Deployed in a Shared Cable Bundle to which a Legacy ADSL System or Deployment Class System that uses Downstream spectrum below 2.208 MHz has been Deployed at a Higher NRP, the System can claim deemed compliance if the following conditions are satisfied.

6.2.3.2   For direct compliance to protect an unshaped Legacy System transmitting from a Higher NRP, it is sufficient to use one of the set of VDSL2 DPBO PSD Masks defined in section 6.3.

6.2.3.3   Selection of the correct DPBO PSD Mask for 6.2.3 is based on the same rules as outlined in Telstra's submission on Non-Deployment Class Systems for C559, which is provided in Appendix C, with a further option to select one of the optional DPBO PSD Masks in Appendix D. It is recommended that the selection of the compliant DPBO

PSD Mask attenuation lies close to the average of the set of permitted attenuations.

6.2.3.4　The 6dB DPBO PSD Mask is newly defined in this Code and does not appear in Telstra's original submission. In cases where the rules in Appendix C result in a 0 dB and/or a 12 dB shaper, the 6dB DPBO PSD Mask may optionally be used instead, provided it meets the additional Deployment rules outlined in Appendix D.

6.2.4　**Shaped System at a Higher NRP**

6.2.4.1　Where there is already a DPBO shaped Legacy System DSLAM at a higher or Lower NRP (and necessarily another Legacy System DSLAM at the Highest NRP), it is also sufficient to use one of the set of ADSL2+ DPBO PSD Masks defined in section 6.3.

6.2.4.2　The correct DPBO PSD Mask to satisfy Section 6.2.4.1 is that shaper closest to the sum of
(a) the nominal 300 kHz attenuation of the DPBO PSD Mask used at the Higher NRP and
(b) the cable path attenuation at 300 kHz between that Higher NRP and the proposed System NRP (with adjustment for Tail Cables as in Equation 3).

EQUATION 3
DPBO PSD Mask Selection

Formulae	Notes
$DM_{300kHz} = nearest(PM_{300kHz} + PTA_{300kHz} - OTA_{300kHz})$	DPBO PSD Masks are labelled according to attenuation DM or PM at 300 kHz. PTA: Prior Legacy System Tail Attenuation OTA: Other System Tail Attenuation PM: Prior Legacy System Mask DM: DPBO PSD Mask for other System

6.2.4.3　The function 'nearest' selects from the set of shapers defined in Section 6.3 the nominal DPBO PSD Mask attenuation that is nearest to the calculated loss difference after adjusting PM_{300kHz} for Tail Cable attenuation differences (in dB on a linear scale)

6.2.5　The DPBO PSD Masks approved for deployment under C559 and the DPBO PSD Masks defined in section 6.3 are each labelled by a nominal attenuation value. That attenuation value is specified at 300 kHz.
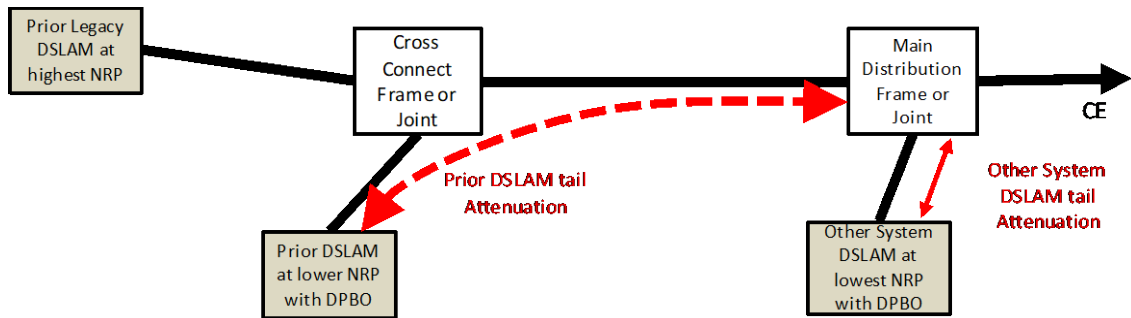
FIGURE 2

Example of a situation requiring application of a DPBO PSD Mask

6.2.6   The situation shown in Figure 2 depicts the other System at a Lower NRP than the Legacy System or Deployment Class System. The method for determining DM_{300k} explained in Equation 3 is also valid if the other System is Deployed at a Higher NRP than the Legacy System or Deployment Class System. In that case, the value of $PTA_{300kHz} - OTA_{300kHz}$ is likely to be negative.

6.2.7   If an accurate model of the attenuation characteristics of a Tail Cable is known at all relevant frequencies, that model may be used to derive the cable attenuation value at 300 kHz, provided that the technical details of the model are made available upon request. Otherwise, per kilometre cable attenuation values at 300 kHz must be derived using the process in Section 7.6.

6.2.8   Upon request, the Provider of a Legacy System or shaped Deployment Class System must promptly provide the requestor with the specific DPBO PSD Mask applied to that System and the tail attenuation between that System and the Main Distribution Frame or Joint at which the other System interconnects.

> NOTE: Providing this information is necessary to avoid delay in facilitating the harmonious coexistence of Systems.

6.3   The library of DPBO PSD Masks

6.3.1   The PSD Masks defined in this section constitute the library of DPBO PSD Masks.

> NOTE: The DPBO PSD Masks described in Figure 3 differ slightly from the Non-Deployment Class System Shaped PSD Masks defined by Telstra in its approved submission to Communications Alliance (refer to Appendix C for more information).
>
> The DPBO PSD Masks defined in Telstra's submission returned to a maximum PSD level of -60 dBm / Hz, reflecting a limitation of the ADSL technology to which those DPBO PSD Masks applied, whereas the DPBO PSD Masks in this code return to the higher limit PSD level described in ITU-T G.993.2 reflecting the capabilities of VDSL2 Systems.

6.3.2   They should be interpreted as Template PSD levels unless otherwise noted. Limit PSD Mask coordinates, which may be required when configuring some kinds of DSLAM, are 3.5 dB higher than the Template PSD Mask coordinate levels.
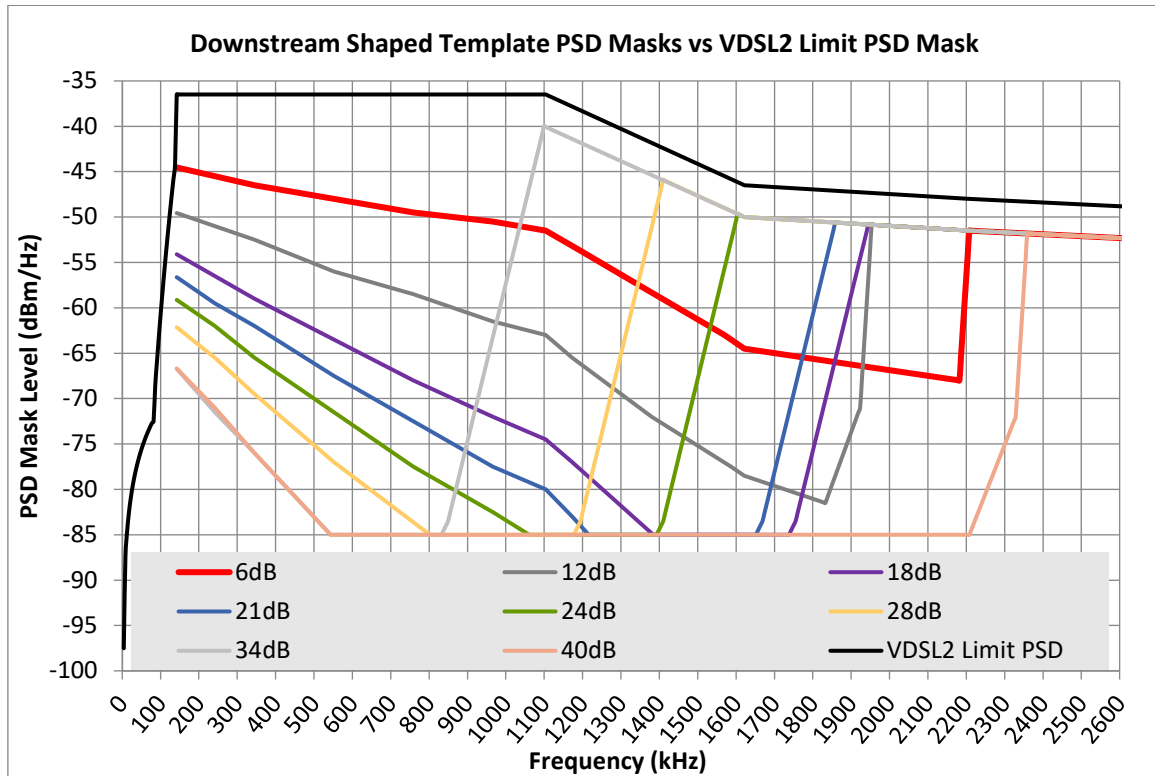
FIGURE 3

**Library of DPBO PSD Template Masks
compared with the unshaped VDSL2 Limit PSD Mask**

6.3.3   The attenuation value that defines each DPBO PSD Mask name refers to nominal attenuation of that PSD Mask at 300 kHz. The Tail Cable attenuations between the Prior Legacy System DSLAM at the Highest NRP and the CCF, MDF or joint to which the shaped System is attached, as described in Figure 2, are used to select the correct PSD Mask as described in 6.2.3 and 6.2.4.

6.3.4   The DPBO PSD Mask Coordinates specified in Tables 2 to 10 use linear interpolation between all coordinate pairs in accordance with Equation 2.

TABLE 2
6dB DPBO Template PSD Mask coordinates

Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)
138	-44.5	966	-50.5	1621.5	-64.5
241.5	-45.5	1104	-51.5	1940.625	-66.5
345	-46.5	1185.9375	-53.5	2182.125	-68
552	-48	1367.0625	-58	2208	-51.5
759	-49.5	1569.75	-63	3750	-54.7

TABLE 3
12dB DPBO Template PSD Mask coordinates

Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)
138	-49.5	1104	-63	1923.375	-71
241.5	-51	1173	-65.5	1953.5625	-50.85
345	-52.5	1380	-72	2208	-51.5
552	-56	1587	-77.5	3750	-54.7
759	-58.5	1621.5	-78.5		
966	-61.5	1832.8125	-81.5		

TABLE 4
18dB DPBO Template PSD Mask coordinates

Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)
138	-54	966	-72	1755.1875	-83.5
241.5	-56.5	1104	-74.5	1944.9375	-50.83
345	-59	1173	-77	2208	-51.5
552	-63.5	1384.3125	-85	3750	-54.7
759	-68	1737.9375	-85		

TABLE 5
21dB DPBO Template PSD Mask coordinates

Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)
138	-56.5	966	-77.5	1668.9375	-83.5
241.5	-59.5	1104	-80	1858.6875	-50.61
345	-62	1173	-83	2208	-51.5
552	-67.5	1216.125	-85	3750	-54.7
759	-72.5	1651.6875	-85		

TABLE 6
24dB DPBO Template PSD Mask coordinates

Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)
138	-59	966	-82.5	1621.5	-50
241.5	-62	1060.875	-85	2208	-51.5
345	-65.5	1392.9375	-85	3750	-54.7
552	-71.5	1410.1875	-83.5		
759	-77.5	1604.25	-49.66		

TABLE 7
28dB DPBO Template PSD Mask coordinates

Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)
138	-62	802.125	-85	1621.5	-50
241.5	-65.5	1177.3125	-85	2208	-51.5
345	-69.5	1194.5625	-83.5	3750	-54.7
552	-77	1410.1875	-45.91		

TABLE 8
31dB DPBO Template PSD Mask coordinates

Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)
138	-64	664.125	-85	1621.5	-50
241.5	-68.5	961.6875	-85	2208	-51.5
345	-73	983.25	-83.5	3750	-54.7
552	-81	1216.125	-42.16		

TABLE 9
34dB DPBO Template PSD Mask coordinates

Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)
138	-66.5	832.3125	-85	2208	-51.5
241.5	-71.5	849.5625	-83.5	3750	-54.7
345	-76	1099.6875	-40		
543.375	-85	1621.5	-50		

6.3.5   The DPBO PSD Mask described by Table 9 is only to be used in situations such as shown in Figure 2 when DPBO PSD Masks are required at two or more DSLAMs that are physically separated. In these cases, the DSLAM which is furthest from CE applies the nominal DPBO PSD Mask for its location, and all DSLAMs closer to CE apply the DPBO PSD Mask which best fits the formula in Equation 3.

6.3.6   Where there are two or more shaped Systems as in Figure 2, and the calculated DPBO PSD Mask is nearer to 40dB than the highest C559 DPBO PSD Mask at 34 dB, the '40dB' DPBO PSD Mask described by Table 10 should be used.

TABLE 10
40dB DPBO Template PSD Mask coordinates

Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)	Frequency (kHz)	PSD Mask Level (dBm/Hz)
138	-66.5	543.375	-85	2358.9375	-51.82
241.5	-71	2208	-85	3750	-54.7
345	-76	2328.75	-72		
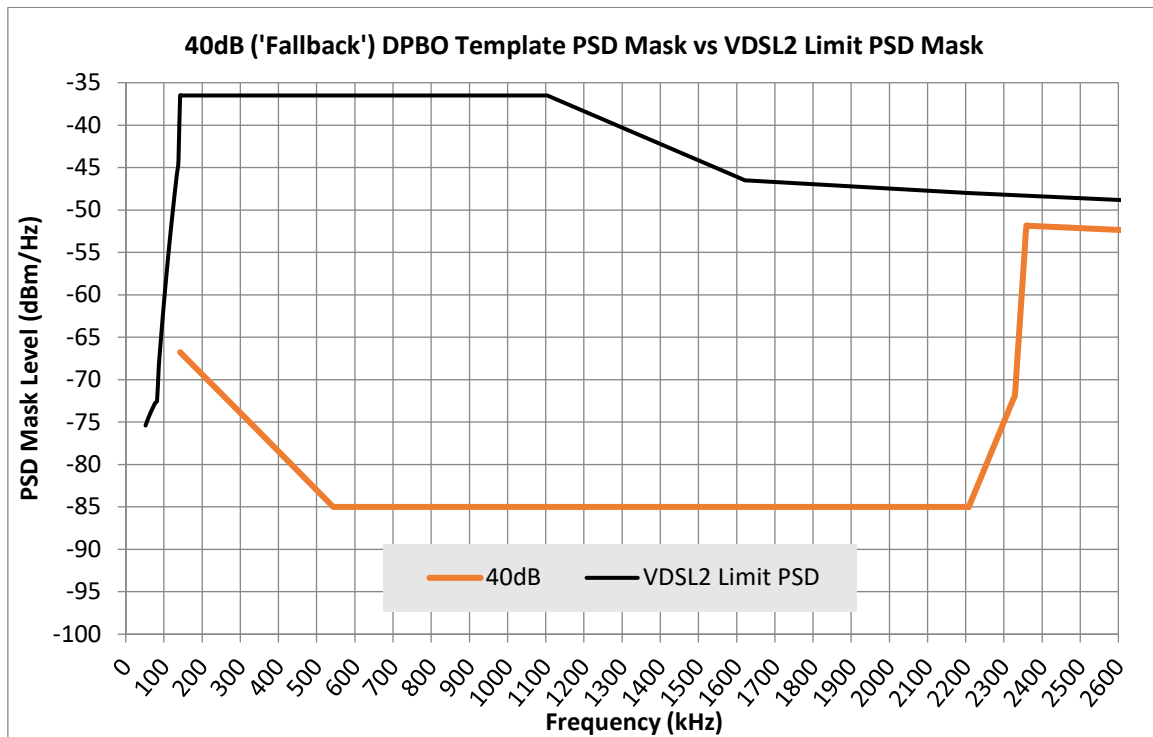
FIGURE 4
The 40dB DPBO Template PSD Mask

6.4 Roll Off at band edges and avoidance of interference (Informative)

6.4.1 Frequently, PSD Masks with one or more vertical slopes (step changes in PSD level) such as those PSD Masks described in Section 6.3 may inadvertently cause Systems to emit spurious emissions in adjacent bands. Generally, the presence of such spurious emissions will not be apparent as an operator alarm or warning and would only be detectable using specialised equipment such as an appropriately capable spectrum analyser.

6.4.2 The ITU-T VDSL2 Recommendation G.993.2 section 7.2.1.1 specifies slopes with lower gradient than some of the PSD Mask gradients in the library of DPBO PSD Masks. It is therefore expected that

Systems including VDSL2 Systems, may require adaptation of their Downstream Shaped PSDs in order to satisfy the requirements of this Code. Any necessary adaptation is likely to be System specific.

6.4.3   When designing and configuring any PSD Mask, including designing and configuring a DPBO PSD Mask for a Deployment Class System, the designer or System Provider is expected to follow the requirements of Section 6.3 in every case. This means that in practice, the implementation of PSD Masks may require roll off at the band edges to ensure compliance with the PSD Mask.

7 METHOD FOR UNACCEPTABLE INTERFERENCE CALCULATION

7.1 Basis of Approach

7.1.1 All Systems cause Far End Crosstalk and Near End Crosstalk, even to other Systems of the same type, as a consequence of the physics of transmission lines and Shared Cable Bundles. Because crosstalk is an unavoidable natural phenomenon, a certain small amount of Interference should be tolerated by every System.

7.1.2 If the level of Far End Crosstalk or Near End Crosstalk caused by a System is too high, that System is said to be causing Unacceptable Interference. The purpose of this section is to define the upper limits to a System's transmit PSDs in order to limit the amount of Interference that a System may cause.

7.1.3 This Code defines certain combinations of Deployment Class System which are able to harmoniously coexist, providing each System is designed, configured and operated according to Deployment conditions that are described in the definition of the Deployment Class System.

7.1.4 If a System is designed, configured and operated according to the Deployment conditions described in the definition of that Deployment Class System, the Code provides for that System to be deemed to coexist with certain other Higher Priority Deployment Class Systems, as defined in Tables 2 and 3 of Part 1.

7.1.5 When a System satisfies the Deemed Coexistence requirements for a Higher Priority Deployment Class System, its Provider is not required to satisfy the Coexistence Masks for that Higher Priority Deployment Class System.

7.2 Difference of approach compared with C559

7.2.1 This Code applies to Systems which operate over Network, Access and Customer Cables. C559 does not apply to Systems using only Customer Cables.

7.2.2 C559 requires every deployment to be spectrally compatible with every protected basis system, regardless of the actual combination of deployment class systems and non-deployment class systems that are deployed to a particular Shared Cable Bundle. The C559 approach, while valid, is technically conservative and it would be onerous to contemplate the same approach in this Code, especially with the advent of Vectoring in contemporary DSL technologies.

7.2.3 In this Code, Deployment Class Systems that meet the requirements of the Deployment Class description can be Deployed to a Shared Cable Bundle if they meet the deemed coexistence requirements for all Higher Priority Deployment Class Systems Deployed to that Shared Cable Bundle.

7.2.4 Deployment Class System combinations or arrangements that do not satisfy the particular conditions for deemed coexistence cannot be deemed to coexist. However a lower priority System may still be able to coexist with a Higher Priority Deployment Class System if it satisfies the Coexistence Masks for that System.

7.2.5 The deemed coexistence requirements for a System in this Code are that:

(a) the System is a Deployment Class System listed in Table 2 or 3 of Part 1 as able to coexist with all Higher Priority Deployment Class Systems sharing the Shared Cable Bundle; and

(b) where deployment parameters have been specified for any equal or Higher Priority Deployment Class System which is not the complementary split spectrum System of the System, the System must use those specified parameters.

7.2.6 In the Upstream direction, different modems are located at different attenuations from their host DSLAM, and it is necessary to generate multiple Upstream Coexistence Masks for different other-System CE locations, based on the Deployment Class System parameters and mode settings.

The other System must be demonstrated to comply with those Coexistence Masks at all possible CE locations within the feeding area of the Shared Cable Bundle. To meet the Coexistence Mask for a non-Vectored Deployment Class System, it is sufficient for the other System to be co-located (i.e. to have equivalent tie cable attenuation) and use the same UPBO parameters and settings as the non-Vectored Deployment Class System in shared bands so that PSD levels from the other System CE will be equivalent to hypothetical PSD levels from Deployment Class System CE if the Deployment Class System CE were to be Deployed at the other System's CE location. Otherwise there would need to be some adjustment of UPBO parameters for the separation of the DSLAMs.

7.2.7 Except as in 7.2.9, the interference from another System is controlled by requiring that the other System's PSD in each direction does not exceed the Coexistence Mask of the Deployment Class System in that direction. If the Deployment Class System is a Vectored System, the Coexistence Mask must be adjusted by reducing its level in accordance with Section 7.8.

> NOTE: To simplify compliance calculations, there is no requirement under this Code to directly calculate all combinations of crosstalk or to determine and compare bit rate outcomes for the Coexisting Systems. Comparing the other System's PSD against the applicable Coexistence Masks is sufficient to demonstrate compliance.

7.2.8 When a Non-Deployment Class System does not meet the same International Standard as the Deployment Class System being protected from Unacceptable Interference, that

Non-Deployment Class System's envelope of PSD must always remain below the Coexistence Mask which is interpreted as a Limit PSD Mask even though it is derived from the nominal Template PSD Mask of the Deployment Class System.

7.2.9 A Non-Deployment Class System that is based on the same International Standard as the Deployment Class System to be protected, is permitted to satisfy the Deployment Class System's Coexistence Mask by interpreting the Coexistence Mask as a Template PSD Mask.

> *NOTES:*
>
> *1. This requirement may permit Deployment of a System that is almost identical to a Deployment Class System that is deemed to coexist, but differs in some aspect that does not impact on Unacceptable Interference. However, where a Non-Deployment Class System is not based on the same International Standard as the Deployment Class System to be protected, it is necessary to comply with the Deployment Class System's Coexistence Mask by interpreting that Coexistence Mask as a Limit PSD Mask.*
>
> *2. "Based on the same International Standard" means:*
>
> *(a) that line coding scheme and Limit PSD Mask of the Non-Deployment Class System are based on the same International Standard defining the Deployment Class System;*
>
> *(b) that the line coding scheme that is actually used by the Non-Deployment Class System is the same as used by the Deployment Class System; and*
>
> *(c) the Limit PSD Mask of the Non-Deployment Class System does not exceed the Limit PSD Mask of the Deployment Class System in any frequencies or any tone which may be used to carry Coded Data by the Deployment Class System.*

7.2.10 Section 7.6 defines the methods for generation of the Upstream Coexistence Masks for a Deployment Class System that uses UPBO. The Deployment Class System UPBO a and b parameters and the relevant AELE-MODE are required to undertake this calculation.

7.3 The Crosstalk Interference Environment and Coexistence Masks

7.3.1   The general representation of the cable crosstalk environment is shown in Figure 5.
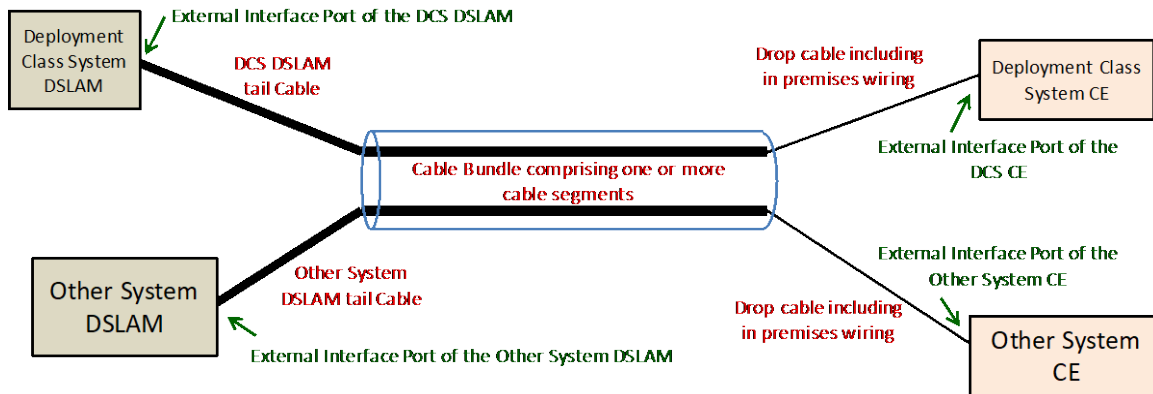
FIGURE 5
Cable Crosstalk Environment

7.3.2   The Systems that must be protected from crosstalk interference are the Higher Priority Deployment Class Systems, each consisting of one DSLAM and its CE. The Systems which may potentially interfere (and therefore need to be constrained in order to comply with this Code) are the other Systems (lower priority), each consisting of one DSLAM and its CE.

7.3.3   In general, Systems cause crosstalk interference to each other in the following modes, which are addressed in turn in Sections 7.4 to 7.7:

(a)   Downstream signals cause Far End Crosstalk (FEXT) into the Downstream receivers of other System CE, causing interference that impacts on performance only within the Downstream band of the Victim Deployment Class System.

(b)   Downstream signals cause Near End Crosstalk (NEXT) into the Upstream receivers of other System DSLAMs, causing interference that impacts performance only within the Upstream band of the Victim Deployment Class System.

(c)   Upstream signals cause FEXT into the Upstream receivers of other System DSLAMs, causing interference that impacts on performance only within the Upstream band of the Victim Deployment Class System.

(d)   Upstream signals cause NEXT into the Downstream receivers of other System CE, causing interference that impacts performance only within the Downstream band of the Victim Deployment Class System.

7.3.4   The crosstalk in the first two cases of 7.3.3 is constrained by the Downstream Coexistence Mask for the Deployment Class System. That Coexistence Mask constrains the transmitted PSD from any

other System in the Downstream direction to a level that does not degrade the Higher Priority Deployment Class System any more severely than crosstalk from other like Deployment Class Systems.

7.3.5 The latter two cases of 7.3.3 are represented by the Upstream Coexistence Mask for a Deployment Class System. That Coexistence Mask constrains the transmitted PSD in the Upstream direction to a level that does not degrade the Higher Priority Deployment Class System any more severely than crosstalk from other like Deployment Class Systems.

7.4 Protecting Deployment Class System Downstream signals against FEXT from another System's DSLAM

7.4.1 Protection of the Deployment Class System Downstream channel against FEXT from the other System's DSLAM requires definition of the Deployment Class System Downstream Coexistence Mask. The Downstream Coexistence Mask applies at the External Interface Port of the Deployment Class System DSLAM.

7.4.2 The method for deriving a Downstream Coexistence Mask is described as:

(a) If the Deployment Class System is a non-Vectored System, its Downstream Coexistence Mask is the same as its Downstream Limit PSD Mask, in both Upstream and Downstream bands of that Deployment Class System.

(b) If the Deployment Class System is a Vectored System, its Downstream Coexistence Mask is offset from its Limit PSD Mask by the specified Maximum Vectoring Gain for that Deployment Class System in Downstream bands that are Vectored, and remains the same as its Limit PSD Mask in Upstream bands and Downstream bands that are non-Vectored. The process for offsetting the Limit PSD Mask is described in Section 7.8, and is called Adjustment.

7.4.3 To determine compliance, the other System Provider must refer the other System transmit PSD to the External Interface Port of the Deployment Class System DSLAM. The process for referral of the other System PSD to the External Interface Port of the Deployment Class System DSLAM is described in Equation 4 and Figure 6.

The process of referral ensures equal PSD levels within the Shared Cable Bundle for all Systems and with reference to Figure 6, requires use of:

(a) the cable path loss OTA(f) between the other System DSLAM and the entry to the Shared Cable Bundle; and

(b) the cable path loss DTA(f) between the Deployment Class System DSLAM and the entry to the Shared Cable Bundle.
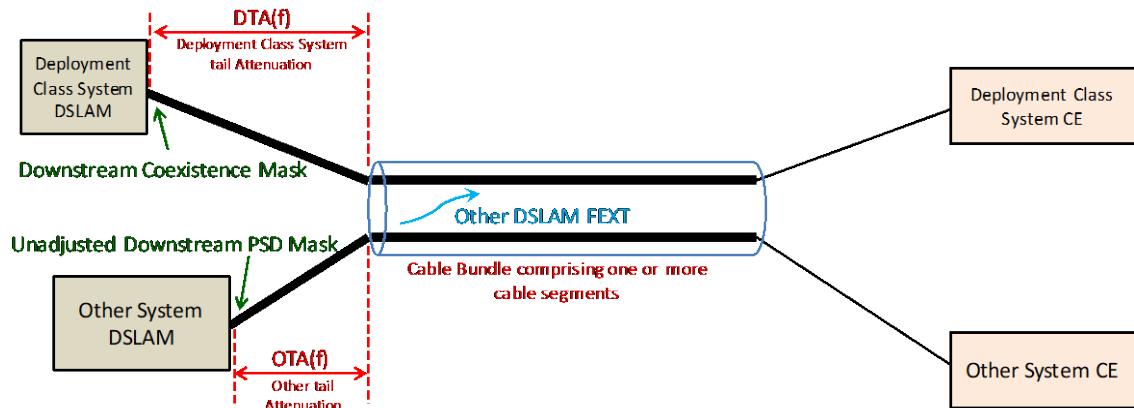
Protecting Higher Priority Deployment Class System Downstream signals against other DSLAM FEXT

7.4.4   To comply with this Code, the referred Downstream Limit PSD Mask of the other System's DSLAM must not exceed the Adjusted Downstream Coexistence Mask of the Deployment Class System when the two PSD Masks are compared at the Deployment Class System DSLAM. This simplified approach ignores the diminution of crosstalk due to the effects of FEXT length.

7.4.5   Only frequencies in the Downstream bands of the Deployment Class System need be considered when assessing the protection of the Deployment Class System signals against other DSLAM FEXT.

PSD for referral to the External Interface Port of the Deployment Class System DSLAM for purpose of determining Downstream FEXT compliance

Formulae	Notes
$$PSD_{ref}(f) = PSD_{other}(f) - OTA(f) + DTA(f)$$ $$PSD_{ref}(f) \leq DCM(f), \quad in\ bands\ being\ protected$$	$PSD_{other}(f)$ is the limit mask of the other System within the Deployment Class System Downstream bands $PSD_{ref}(f)$ is the referred Limit PSD Mask of the other System. DCM(f) is the Downstream Coexistence Mask for the Deployment Class System DSLAM PSD is expressed in dBm/Hz

NOTES:

1. Refer to Section 7.8 for details about PSD Mask adjustment which is required when generating Coexistence Masks for Vectored Deployment Class Systems.

2. Section 16 describes methods for calculation of cable attenuations in this formula.

7.5 Protecting Upstream signals against NEXT from another System's DSLAM

7.5.1 Protection of the Deployment Class System Upstream channel against NEXT from the other System's DSLAM requires definition of the Deployment Class System Downstream Coexistence Mask. The Downstream Coexistence Mask applies at the External Interface Port of the Deployment Class System DSLAM.

7.5.2 In order for the other System's DSLAM to comply with this Code, the level of NEXT caused by its Downstream transmissions must not exceed the level of NEXT caused by the Deployment Class System DSLAM's Downstream transmissions to its own Upstream services. The calculations are outlined in the following steps, Figure 7 and Equation 5.

7.5.2.1 Firstly, the other System Downstream PSD is first referred to the entry of the Shared Cable Bundle, attenuating that PSD.

7.5.2.2 Secondly, a NEXT calculation is performed using the attenuated other System PSD.

7.5.2.3 Thirdly, that calculated NEXT is itself referred back to the External Interface Port of the Deployment Class System DSLAM.

7.5.2.4 Fourthly, the nominal level of NEXT introduced by the Deployment Class System Downstream services to its own Upstream frequencies is determined. This result should correspond to the Deployment Class System Downstream Template PSD Mask in the Deployment Class System Upstream bands.

7.5.2.5 Lastly, a verification is performed at all Deployment Class System Upstream frequencies being protected confirming that the referred other System NEXT does not exceed the NEXT caused by the Deployment Class System to itself.
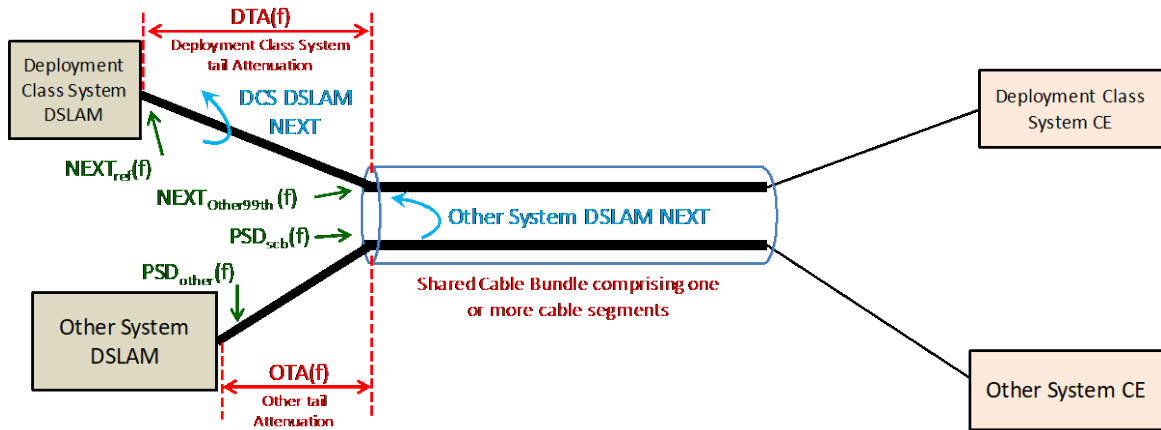
FIGURE 7
PSD for referral to the External Interface Port of the Deployment Class System DSLAM for purpose of determining Downstream NEXT compliance

EQUATION 5
Derivation of a Deployment Class System Upstream Coexistence Mask and application to another System

Formulae	Notes
$N_{99th}(f,n) = 15\log_{10}(f) + 6\log_{10}\left(\dfrac{n}{4}\right) - \begin{cases} 61.5, & only\ Cat5\ or\ Cat6\ cables \\ 40.5, & other\ or\ mixed\ cables \end{cases}$ $PSD_{scb}(f) = PSD_{other}(f) - OTA(f)$ $NEXT_{Other\ 99th}(f,n) = PSD_{scb}(f) + N_{Other\ 99th}(f,n)$ $NEXT_{ref}(f,n) = NEXT_{Other\ 99th}(f,n) - DTA(f)$ $NEXT_{DCS\ 99th}(f,n) = PSD_{DCSdown}(f) + N_{DCS\ 99th}(f,n)$ $NEXT_{ref}(f,n) \le NEXT_{DCS\ 99th}(f,n)$ $\quad$ *in bands being protected*	f is expressed in MHz the value of n is 8 in this calculation PSD_{Other}(f) is the Limit PSD Mask of the Other System within the Deployment Class System Upstream bands NEXT and PSD are expressed in dBm/Hz

Further Requirements for use of Equation 5:

1. If both the Tail Cable and Shared Cable Bundle relevant to an N_{99th} calculation comprise only Cat5 or Cat6 cable segments, the constant 61.5 is used in Equation 5, otherwise the constant 40.5 is used.

2. Let the difference between the crosstalk constants ΔN be defined as $\Delta N = N_{Other\ 99th}(f,n) - N_{DCS\ 99th}(f,n)$

If the Deployment Class System Tail Cable and the Shared Cable Bundle are entirely Cat5 or Cat6 cables, and the other Tail Cable is not, then ΔN = −21.0. Conversely, if the other Tail Cable and the Shared Cable Bundle are

entirely Cat5 or Cat6 cables, and the Deployment Class System Tail Cable is not, then ΔN = +21.0. Otherwise, ΔN = 0.

If the other System is the same type of System as the Deployment Class System, then Equation 5 reduces to
$$PSD_{other}(f) - OTA(f) - DTA(f) - \Delta N \leq PSD_{DCSdown}(f) \quad \textit{in bands being protected}$$

which involves only a comparison of the referred other System Downstream Limit PSD Mask and Deployment Class System Downstream Limit PSD Mask, and is therefore simpler to verify.

7.6 Protecting Deployment Class System Upstream signals against FEXT from another System's CE

7.6.1 Protection of the Deployment Class System Upstream channel against FEXT from the other System's CE requires definition of the Deployment Class System Upstream Coexistence Mask. The FEXT component of the Upstream Coexistence Mask applies at the External Interface Port of the other System's CE within the frequency ranges containing the Upstream Deployment Class System signals that are to be protected.

7.6.2 The method for deriving the Upstream Coexistence Mask within the Upstream band of the Deployment Class System is described in the next paragraphs.

7.6.2.1 If a Deployment Class System does not support UPBO and is non-Vectored in any Upstream bands, its Reference Upstream Coexistence Mask in those bands should be set to the Upstream Template Mask for that Deployment Class System.

7.6.2.2 If a Deployment Class System does not support UPBO and is Vectored in any Upstream bands, its Upstream Coexistence Mask in those bands should be offset downwards from its Template PSD Mask by a margin equal to its Maximum Vectoring Gain Upstream,

7.6.2.3 If a Deployment Class System supports UPBO and is non-Vectored in any Upstream bands, its Upstream Coexistence Mask in those bands should be derived from its Upstream Template PSD Mask after that PSD Mask has undergone UPBO adjustment described in Section 9.

7.6.2.4 If a Deployment Class System supports UPBO and is Vectored in any Upstream bands, its Upstream Coexistence Mask in those bands should be derived from its Upstream Template PSD Mask after that PSD Mask has undergone UPBO adjustment as described in Section 9, and then further offset downwards by a margin equal to its Maximum Vectoring Gain Upstream.

7.6.3 Generation of the Deployment Class System Upstream Coexistence Mask requires use of the cable path loss H(f)

between the other System CE and the Deployment Class System DSLAM.

7.6.4 The cable path loss between the other System CE and the Deployment Class System DSLAM is the loss which would be incurred if a cable path is jumpered from the proposed other System CE location all the way back to the Deployment Class System DSLAM. The process for determining the cable path loss is outlined in Section 8.

7.6.5 From a single DSLAM location, there will always be many potential CE locations which must be considered, as shown in Figure 8.
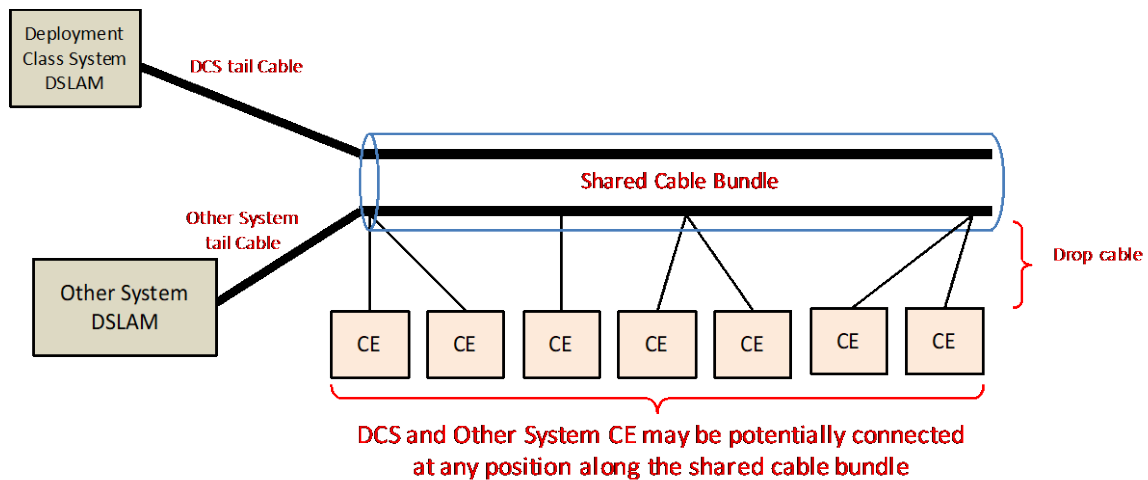
FIGURE 8

CE may be positioned at any potential location along the Shared Cable Bundle

7.6.6 The Deployment Class System Tail Attenuation DTA(f) and the Drop Attenuation D(f) are constants for any specific installation, but the attenuation to be used for the Shared Cable Bundle Attenuation SCB(f) should be varied in accordance with all potential positions at which drop cables may join the Shared Cable Bundle. The variation of potential drop cable branching points is shown in Figure 9.

7.6.7 DTA(f) represents an access network cable, including a potential drop cable on the network side of a premises MDF (from the street into the premises). Its attenuation must be determined from cable segment and length information which is provided or made available by the access Network Provider using cable models defined in Section 15.
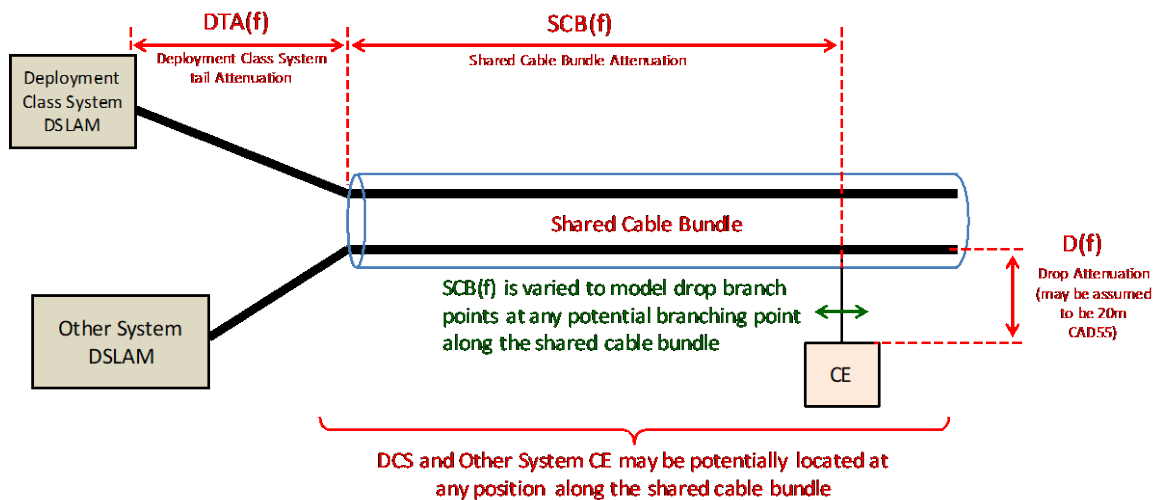
FIGURE 9

Determination of the end to end Insertion Loss requires variation of the position of the Lead-In branching point

7.6.8 To determine compliance, the other System operator must demonstrate that none of the other System CE will cause or is likely to cause Unacceptable Interference due to FEXT into the Deployment Class System CE signals Upstream.

The only way to demonstrate this is by showing that other System CE meets the particular UCM that specifically applies at each possible CE location.

7.6.9 If the Deployment Class System supports UPBO, a different UCM applies at each potential CE location.

7.6.9.1 For Deployment Class Systems that support UPBO, UPBO must be incorporated when determining the UCM that applies at each CE location. The method for applying UPBO is outlined in Section 9.

7.6.9.2 A separate UPBO calculation is required for each potential other System CE location.

7.6.9.3 The Deployment Class System's UPBO AELE-MODE and per band a and b parameters must be used when determining the applicable Upstream Coexistence Masks.

NOTES:

1. The a and b UPBO parameters applied by the Deployment Class System may be different for each Upstream band used by the Deployment Class System.

2. Multiple UCMs apply according to location because H(f) attenuation varies according to CE location and the outcome of the Deployment Class System UPBO adjustment depends on H(f).

3. VDSL2 and G.fast technology types support UPBO.

7.6.10   For the purpose of determining compliance with this Code, a resolution no coarser than 0.5dB (at 3.75 MHz) should be verified between potential CE locations along the Shared Cable Bundle.

7.6.11   Only frequencies in the Upstream bands of the Deployment Class System need be considered when assessing the protection of the Deployment Class System Upstream signals against other System CE FEXT.

7.6.12   The Deployment Class Descriptions in Part 3 include a Reference Upstream Coexistence Mask that represents the maximum Upstream PSD transmitted by a CE that is at a higher attenuation from the DSLAM than the UPBO Reference Attenuation.

7.7   Protecting Deployment Class System Downstream signals against NEXT from another System's CE

7.7.1   Protection of the Deployment Class System Downstream channel against NEXT from other System CE is based on the Deployment Class System Upstream Coexistence Mask in the spectrum used for Deployment Class System Downstream transmissions. The Upstream Coexistence Mask applies at the External Interface Port of the System CE. The method for deriving that part of the Upstream Coexistence Mask in the Upstream bands of the Deployment Class is described in Section 7.6.

7.7.2   To determine compliance, the other System Provider must compare the level of NEXT originating from the other System CE and the level of NEXT originating from the Deployment Class System CE. The calculations are outlined in the following steps, Figure 10, Figure 11 and Equation 5.

   7.7.2.1   In order to perform this verification, the other System Upstream Limit PSD is first referred to the entry of the Shared Cable Bundle, attenuating that PSD in accordance with $D_{Other}(f)$ shown in Figure 11.

   7.7.2.2   Secondly, a NEXT calculation is performed using the attenuated other System PSD, in accordance with Equation 5.

   7.7.2.3   Thirdly, that calculated NEXT is itself referred back to the External Interface Port of the Deployment Class System CE attenuating that PSD in accordance with $D_{DCS}(f)$ shown in Figure 11.

   7.7.2.4   Fourthly, the level of NEXT introduced by the Deployment Class System Upstream services to its own Downstream frequencies is determined. This result should correspond to the Deployment Class System Upstream Template PSD Mask in the Deployment Class System Downstream bands.

   7.7.2.5   Lastly, a verification is performed at all Deployment Class System Downstream frequencies being protected confirming that the referred other System NEXT does not

exceed the NEXT caused by other Deployment Class System CE to itself.

7.7.3   The component of the UCM in the Downstream band of the Deployment Class System applies at the Non-Deployment Class System CE as in Figure 10.
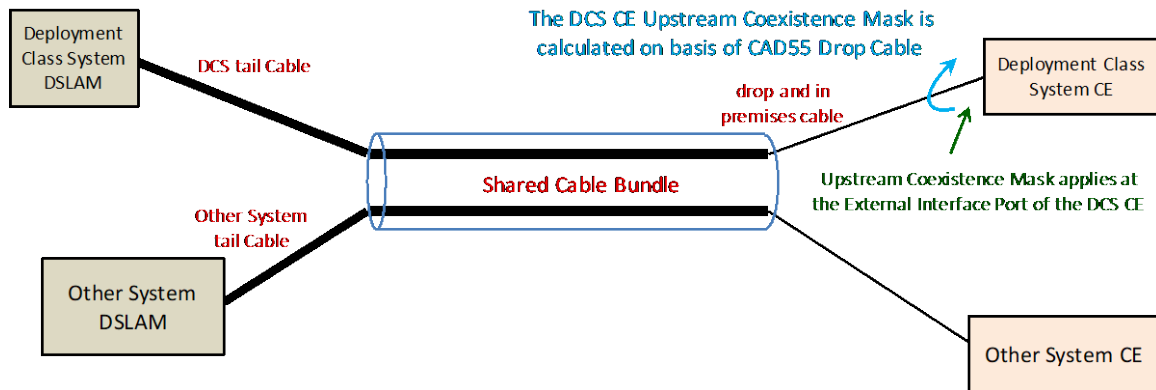
FIGURE 10

Protecting Higher Priority Deployment Class System Upstream signals against other CE NEXT
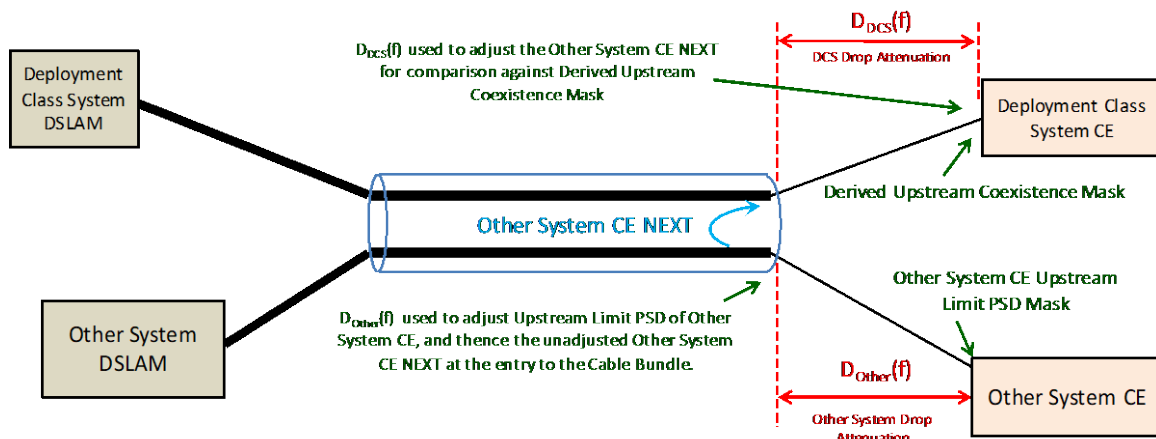
FIGURE 11

Derivation of an Upstream Coexistence Mask in the Downstream band of the Deployment Class System

7.7.4   The component of the UCM in the Deployment Class System Downstream band is set equal to that part of the Upstream PSD Mask of the Deployment Class System.

Because there is no attempt within the Deployment Class System to equalise the NEXT for different attenuation Tail Cables, there is no need for referral of the out-of-band component of the Upstream PSD to the Deployment Class System CE.

Because the Deployment Class System Upstream PSD Mask value at the boundary between Upstream bands and Downstream bands is governed by UPBO, the transition between the value at

the boundary and the Downstream band floor PSD of the UCM will change with attenuation. The rule governing the transition region is that the out-of-band PSD at all frequencies must be less than or equal to the in-band PSD at the boundary.

7.8 Adjusting Vectored Deployment Class System Coexistence Masks to accommodate Vectored bands

7.8.1 For Vectored Deployment Class Systems, Coexistence Masks must be derived from the non-Vectored Coexistence Mask by adjusting that Coexistence Mask down by the Deployment Class System's Maximum Vectoring Gain according to the following paragraphs.

> *NOTE: Non-Vectored Deployment Class System Coexistence Masks do not require adjustment. The method outlined in this section does not apply to the Coexistence Masks of a non-Vectored Deployment Class System.*

7.8.2 Subject to 7.8.3, to derive the Downstream Coexistence Mask for a Vectored Deployment Class System, take the Downstream Coexistence Mask for the non-Vectored equivalent of that Deployment Class System, and reduce that Coexistence Mask level by an amount equal to that Deployment Class System's Maximum Vectoring Gain in accordance with Equation 6 in frequencies or tones used by the Deployment Class System in the Downstream direction and which are available to be Vectored. For all other frequencies or tones, the Downstream Coexistence Mask is identical to Coexistence Mask for the non-Vectored equivalent of that Deployment Class System.

> *NOTE: The purpose of this level reduction is to contain interference from the other System to the equivalent floor level of an effectively Vectored Deployment Class System. The equivalent floor level of an effectively Vectored Deployment Class System is the effective noise level experienced by the Vectored System after it has cancelled as much of its own crosstalk as technically feasible.*

7.8.3 At the transition between a frequency band which has been adjusted by the Deployment Class System's Maximum Vectoring Gain and the adjoining band which has not been adjusted, the slope of the Coexistence Mask should adopt a gradient that is permitted by that System's International Standard, and common System implementations. The gradient should 'eat into' that part of the band which is available for use by the Coexisting System, and avoid the band which is Vectored by the Deployment Class System.

7.8.4 Subject to 7.8.3, to derive the Upstream Coexistence Mask for a Vectored Deployment Class System, take the Upstream Coexistence Mask for the non-Vectored equivalent of that Deployment Class System, and reduce that Coexistence Mask level by an amount equal to that Deployment Class System's Maximum Vectoring Gain in accordance with Equation 6 in

frequencies or tones used by the Deployment Class System in the Upstream direction and which are available to be Vectored. For all other frequencies or tones, the Upstream Coexistence Mask is identical to Coexistence Mask for the non-Vectored equivalent of that Deployment Class System at that CE location.

EQUATION 6
Deriving the Coexistence Mask for Vectored Deployment Class Systems

Formulae	Notes
$$VCM(f) = \begin{cases} max \begin{cases} CM(f) - MaxG_{vect} \\ PSD_{minCE} \end{cases} & for\ f\ vectored \\ min \begin{cases} CM(f) \\ GACM(f) \end{cases} & for\ f\ not\ vectored \end{cases}$$	The Vectored Coexistence Mask VCM(f) has equal or lower PSD at all frequencies compared with the non-Vectored Coexistence Mask CM(f) $MaxG_{vect}$ represents the Maximum Vectoring Gain of the Deployment Class System being protected PSD_{minCE} represents the Minimum Transmit PSD level in Vectored bands of the Coexistence Mask GACM(f) represents the gradient adjusted Coexistence Mask in compliance with the Deployment Class System's International Standard

7.8.5 For VDSL2 Systems, the default value of the $MaxG_{vect}$ constant described in Equation 6 is outlined in Table 15.

7.9 Determination of spectral compatibility with a TDD system

7.9.1 To compare a proposed system (the 'alien') against an equal or higher priority TDD Deployment Class System (the 'victim'), the 'alien' system operator must demonstrate at every potential location where a 'victim' device could be receiving 'victim' system transmissions, the aggregate sum of the interfering 'alien' PSD never exceeds the referred coexistence mask for the 'victim' system at any of the potential 'victim' system receiving locations.

7.9.2 Depending upon the specific underlying system technologies, to adequately demonstrate that an 'alien' system will avoid causing Unacceptable Interference, the applicant may need to consider every potential combination of the 'victim' system modem and DPU location, and every potential combination of the 'alien' system modem and DPU location. When determining potential device locations for this purpose, those potential locations should comply with all applicable Code rules and the 'victim' system deployment requirements.

7.9.3 When the 'victim' system is a TDD system, the critical or limiting calculation will be a NEXT calculation. The critical circumstance will be when the 'victim' receiver is positioned directly on one end of a joining cable section, the 'alien' transmitter is positioned directly on the opposite end of the joining cable section and the 'victim' transmitter is placed at the point of greatest cable

attenuation from the 'victim' receiver within the cable footprint of the 'victim' system being considered.

7.9.4   The procedure for performing NEXT calculations for a Frequency Division Duplex (FDD) system is described in Section 7.5 of part 2 of this Code. When a TDD system is involved, the procedure will be slightly different and may need to be adapted according to the characteristics of the system. For frequencies up to approximately 30MHz, PSD losses along cable paths will predominantly be due to the intrinsic cable attenuation. For increasingly higher frequencies and depending upon the cable types being considered, losses along cable paths may additionally require consideration of NEXT and FEXT effects which may contribute either to signal loss or signal gain along the cable path. The calculations described in Section 7.5 of part 2 of this Code are based on the VDSL2 17a profile using frequencies up to 17.6MHz, so NEXT and FEXT effects were not considered. G.fast technology potentially uses spectrum up to 212 MHz and the effects of NEXT and FEXT may dominate, particularly at higher frequencies, so it is critical to identify and properly consider all third-circuit paths and to consider the effects of NEXT and FEXT as significant components of PSD loss or gain along the cable path.

7.9.5   An example of a potential procedure to verify compliance against an equal or higher priority TDD system, or to propose a new kind of Deployment Class System, could look like:

(a)   Using the Code's coexistence mask for the 'victim' as a starting point, attenuate that PSD along the cable path between 'victim' transmitter and 'victim' receiver.

The calculated received PSD at the 'victim' receiver is the referred coexistence mask at the 'victim' receiver. The aggregate level of 'alien' interference at this point must not exceed a limit comprising the maximum of either that referred coexistence mask level, or the noise floor level at the 'victim' receiver.

For vectored systems such as VDSL2 and G.fast, the coexistence mask is a fixed step below that system's template PSD. The quantum of the step (typically 25dB) corresponds to the 'victim' system's vectoring gain.

(b)   When the aggregate level of 'alien' interference is dominated by 'alien' NEXT and in the case where the 'victim' is a G.fast TDD system deployed in accordance with this Code, the specific dominating NEXT path needs to be identified so the NEXT can be calculated. For example, in a situation where a basement VDSL2 system is feeding services throughout the entire high rise building, and a number of different G.fast TDD systems are to be distributed at different locations up the building riser, the dominant NEXT path from one G.fast system to another will originate on cables wholly within the perimeter of the 'victim' system cable footprint, and make use of 'third-circuit' pairs

associated with the basement VDSL2 system that are within the same cable sheaths as the 'victim' TDD system. For different system and cable topologies, those different system and cable topologies need to be explicitly considered to identify and characterise every noise propagation path.

Using the calculated reference receiver PSD level from step (a), apply the NEXTPSA formula (refer to Appendix B, Section B3) using the deployed cable characteristics and cable length within the 'victim' cable footprint to determine the limiting 'alien' PSD on one pair nominally adjacent to the pairs electrically connected to the 'victim' receiver. If the cable topology is complex, the noise level will involve several steps of calculation and referral.

(c)   Because the 'alien' PSD originates from a physically different location than that of the 'victim' receiver, that 'alien' PSD on a pair adjacent to the 'victim' receiver pairs, must be referenced back to its source location, potentially involving additional NEXT or FEXT calculations as the riser cable and other cables are traversed, taking care to correctly determine whether it is second or third circuit NEXT or FEXT that needs to be accounted and applying the correct and appropriate cable attenuation as well as the correct and appropriate NEXT or FEXT parameters.

NOTE: The full set of steps in the described calculations above is equivalent to a multi-step referral of the original 'victim' coexistence mask along the entire path from the 'victim' transmitter, past the 'victim' receiver and finally to the 'alien' transmitter.

(d)   After allowances for every step along the cables back towards the 'alien' transmitter (or transmitters), and after taking the maximum of that PSD and the noise floor, the resulting PSD mask defines the maximum potential 'alien' template PSD which would permit the 'alien' transmitter to operate in accordance with this Code.

(e)   If the purpose of these calculations is to define and propose a new kind of Deployment Class System, the 'alien's' coexistence mask can be determined by applying a vectoring gain offset (if the 'alien' is vectored) to its template PSD and taking the maximum of the resulting mask and the noise floor.

NOTE: The process of referring and adjusting coexistence masks will normally only be necessary when defining a new Deployment Class System or when demonstrating compliance for non-deployment-class systems. Generally, when deploying one of this Code's existing Deployment Class Systems, deemed compliance is available if the proposed system has been

> *deployed and is operated in full accordance with the Code's rules and requirements.*

8 DETERMINING CABLE PATH ATTENUATION

This section describes the method to be used to determine cable path attenuation at the relevant reference frequency for a Deployment Class for the purpose of determining compliance with this Code.

Cable path attenuation is relevant for a Deployment Class that shares spectrum with another Deployment Class.

For the purpose of this Code, determining cable path attenuation is not required for a Deployment Class that does not and cannot share spectrum e.g. G.fast-SM (refer to Appendix B to Part 3).

Refer to Section 11 (in this Part of this Code) for more information on determining Non-Deployment Class System compliance with the obligation not to create Unacceptable Interference.

8.1 Cable impairments

8.1.1 When calculating cable path attenuation, bridged taps, bad joints, wet cables and any other kind of cable impairment may be ignored, so that only the direct path attenuation of cables in good working order needs to be determined.

> *NOTE: Impaired cables may lead to reduced data rates. If reduced rates are a consideration, impaired cables should be serviced by the cable owner to eliminate the impairments in order for Systems Deployed over those cables to perform in accordance with the expected rates outlined in this Code.*

8.2 Attenuation Percentile

8.2.1 When calculating cable path attenuation, the 50th percentile cable attenuation should be used if a crosstalk calculation that requires cable attenuation uses 50th percentile crosstalk levels.

Models for 50th percentile attenuation for common Australian cables in good working order are described in Section 15.

8.2.2 When calculating cable path attenuation, the 99th percentile cable attenuation should be used if a crosstalk calculation that requires cable attenuation uses 99th percentile crosstalk levels.

The 99th percentile cable path attenuation is derived from the 50th percentile attenuation models described in Section 15, using Equation 7.

EQUATION 7
Deriving the 99th percentile cable attenuation $H_{99th}(f)$

Formulae	Notes
$$H_{99th}(f) = H_{50th}(f) + \frac{l\sqrt{f}}{2}$$	$H_{99th}(f)$ and $H_{50th}(f)$ are expressed as dB losses. l represents the same cable length as used to calculate $H_{50th}(f)$ and is expressed in km. The factor of 2 in the denominator represents a mean attenuation difference of 0.5 dB per km between the 50th and 99th percentiles, expressed at 1 MHz.

NOTE: The cable models described in Section 15 represent the 50th percentile attenuation per km versus frequency. The attenuation of a cable segment is calculated by multiplying the segment length (expressed in km) by the attenuation per km represented by the cable model.

8.3 Attenuation of cable paths consisting of more than one segment

8.3.1 Subject to 8.3.2, when calculating cable path attenuations based upon two or more segments of cable connected in series, the attenuation of each segment is calculated individually and then those segment attenuations (expressed in dB) are summed.

8.3.2 For the purpose of determining Full Coverage, the attenuation of each cable segment may be found using Table 18 in Appendix B. For all other purposes, including simulation of rates and referring PSD Masks, the attenuation of each cable segment must be calculated using the cable models and equations described in section 16.

8.3.3 The cable path attenuation between a DSLAM and CE is the addition of the Tail Attenuation TA(f), the Shared Cable Bundle attenuation SCB(f) and the drop attenuation D(f), as shown in Figure 12 and described by Equation 8.

8.4 Drop cable attenuation

8.4.1 In practice, the drop cable length and characteristics will vary from circumstance to circumstance and would be difficult and onerous to ascertain with certainty. Where required by this Code for the purposes of calculating a cable path attenuation involving a drop cable, the length and type of any drop cable between the CE and the exit point from the specific Shared Cable Bundle which is nearest the CE, may be assumed to be 20m of CAD55 cable.
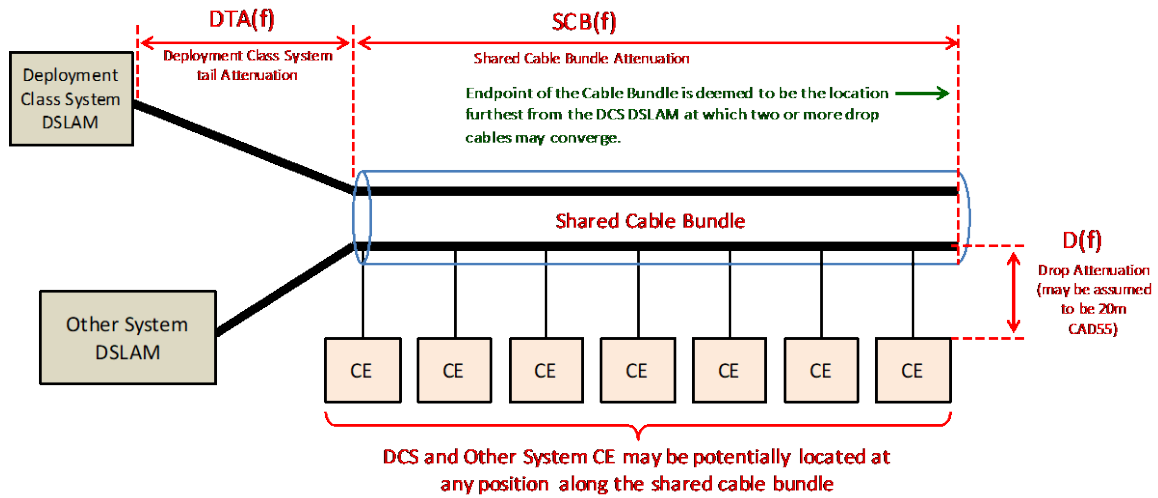
FIGURE 12

**Example of End to End Attenuation involving a Tail Cable,
Shared Cable Bundle, and a Drop Cable**

EQUATION 8

End to end cable path loss H(f)

Formulae	Notes
$H(f) = TA(f) + SCB(f) + D(f)$	Attenuation is assumed to be close to insertion loss.
	The values of TA(f) and D(f) are consistent, but the value of SCB(f) may require variation in accordance with the modelled position of CE along the Shared Cable Bundle.
	The attenuations in this equation are expressed in dB.
	For the purpose of determining Full Coverage, the only frequency requiring consideration is 3.75 MHz.

> *NOTE: a drop cable is a cable that connects from the departure point of the nearest Shared Cable Bundle, into an end user premises and through to the CE. Drop cable includes internal premises wiring. When considering a Shared Cable Bundle other than the nearest one to the customer premises, the drop cable length may be much longer and the assumption is invalid for that Shared Cable Bundle.*

8.4.2   In circumstances where Shared Cable Bundles are cascaded in series, including situations where different overlapping Systems having different coverage areas share dissimilar sets of Shared Cable Bundles as described in Figure 13, the assumed 20m of CAD55 drop cable described in 8.4.1 applies only between the CE and the exit point of the Shared Cable Bundle nearest to that CE.
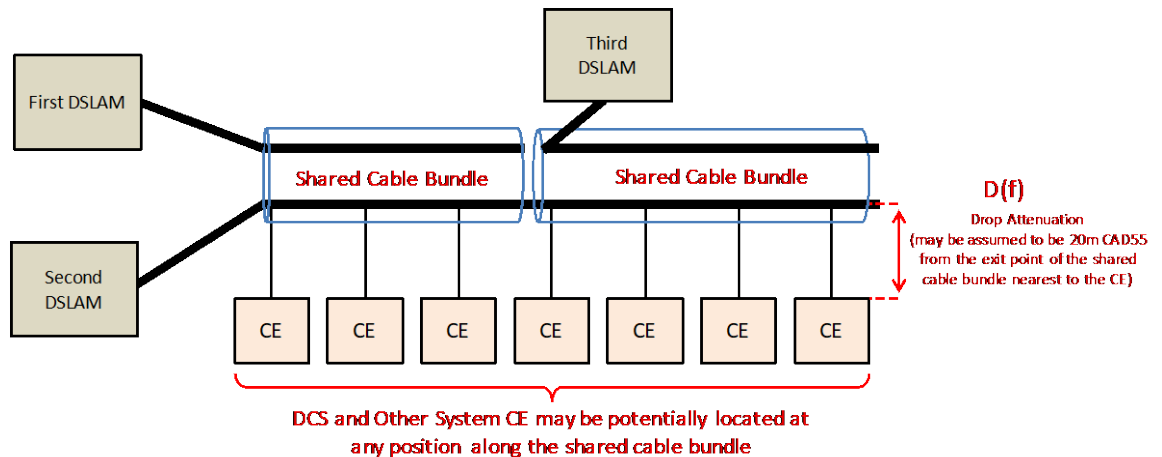
FIGURE 13

Drop cable length and type assumption applies only between the CE and the exit point of the nearest Shared Cable Bundle

8.5　Cable types for the purpose of modelling

8.5.1　If all cable types within a Shared Cable Bundle section are of the Cat5 or Cat6 type, then the Cat5 cable model should be used to represent that Shared Cable Bundle section, otherwise the Cat5 cable model should not be used.

8.5.2　If a Tail Cable or a segment of a Tail Cable is of the Cat5 or Cat6 type, then the Cat5 cable model should be used to represent that Tail Cable or Tail Cable segment, otherwise the Cat5 cable model should not be used.

> *NOTE: The Cat5 cable model is described in Section 16.1.*

8.5.3　Cable segments may be modelled as any of the cable types described in Section 16 if certain that the entirety of the cable segment is the corresponding cable type.

8.5.4　The 'CAD55' cable model should be used to represent any cable segment for which the cable type is certain but a model for that type of cable is not included in Section 16.

> *NOTE: The cable type may be unknown or uncertain if the segment's type is not readily visible from inspection.*

8.5.5　The 'CAD55' cable model should be used to represent any cable segment for which the cable type is uncertain.

8.5.6　The 'CAD55' cable model should be used to represent any cable segment for which the operating frequency range of one or more Systems using that cable segment exceeds the range of frequencies for which the cable model is valid.

8.6 Determination of the topology of deployed cables and types

8.6.1 Subject to Clause 8.6.6.4, Building and Campus System Providers must base their System's operating parameters upon the actual cable topology and cable types that have been deployed.

8.6.2 The actual cable topology is the hierarchy of cable segments and segment lengths, and includes access network cable, in-building cable, and Tail Cables.

8.6.3 Providers of Building and Campus Systems that choose to notify details about their Building or Campus Systems as outlined in Section 12, should include details of the cable topology upon which their designs are based.

> *NOTES:*
>
> *1. The Network Provider does not need to provide details of the cable topology for each building in the footprint of a network FTTN node.*
>
> *2. The harmonious coexistence of Systems depends on correctly configuring each System in accordance with the actual cable topology and cable types. Providing this information is necessary to avoid delay in facilitating the harmonious coexistence of other Systems with a Deployment Class System.*
>
> *3. Providers of subsequent Building and Campus Systems should align their System configurations with the Notified topology details of Higher Priority Systems. For this reason, the Notified topology details should be reasonably consistent with the actual cable topology details in the Building or Campus.*

8.6.4 Where the Deployment Class System is a Network System and the Network Provider has not already Notified the information, the Network Provider must on request provide a loop trace describing the cabling within the access network. The loop trace must state the cable type and length of each segment of cable that makes up the cable path between the Deployment Class System network DSLAM and the NBP.

8.6.5 Shared Cable Bundle records associated with the plant should not be assumed to be accurate at their face values and should be verified to the extent practically feasible. The meaning of practically feasible is described in section 8.6.6.

8.6.6 Cable lengths should be verified as accurately as feasible in accordance with the following methods which are listed in descending order of preference.

    8.6.6.1 The TDR technique configured using a valid propagation constant is the preferred method for determining cable lengths and types.

    8.6.6.2 Cable lengths and types may be determined by direct inspection and direct measurement. It will be generally

most efficient to perform the inspection and measurement at the time of site surveying.

8.6.6.3   Cable lengths may be determined indirectly by summing the path lengths from a plan.

8.6.6.4   Where the length or type of a cable segment is unknown, and cannot be accurately ascertained by inspection or measurement, and there are no Notified details about the cable segment length and type for a Higher Priority System, use a best estimate and document the best estimate so that it can be recalled and shared with other Providers on demand.

NOTES:

1. Differences in end to end cable path lengths of as small as approximately 15m or 0.5 dB at 3.75 MHz will have a noticeable and measurable effect upon UPBO PSD levels. Excess PSD causes additional crosstalk which reduces attainable rates. Length estimation errors as small as 15m will therefore have noticeable effect on attainable Upstream rates.

2. Where feasible, the level of uncertainty in the end to end cable path attenuation should be no greater than 0.5 dB at 3.75 MHz.

---

9 UPSTREAM COEXISTENCE MASK SPECIFICATION FOR DEPLOYMENT CLASS SYSTEMS THAT USE UPSTREAM POWER BACK OFF

9.1 Basis of Approach

9.1.1 This section describes the specification of the Upstream Coexistence Mask for Deployment Class Systems that use Upstream Power Back Off. Similar approaches are required for Vectored and non-Vectored Deployment Class Systems, the difference being that the Coexistence Mask for Vectored Deployment Class Systems involves an additional adjustment offset in bands that are Vectored.

9.1.2 Systems that implement UPBO involve two parameters 'a' and 'b', which are specified for each band that supports UPBO.

> *NOTES:*
>
> *1. For VDSL2 Systems, all Upstream bands except US0 support UPBO.*
>
> *2. For G.fast Systems, the entirety of the used band supports UPBO.*

9.2 Non-Vectored Deployment Class Systems that support UPBO

9.2.1 Where an Upstream band is permitted to be shared by multiple VDSL2 Systems in the same Shared Cable Bundle, the UPBO 'a' and 'b' parameters used by the highest priority Deployment Class System must be selected from the set of options defined in Table 3 of part 3 of this Code.

9.2.2 The AELE-MODE adopted by the highest priority Deployment Class System must be consistent with the Deployment conditions for that Deployment Class System defined in Part 3 of this code.

9.2.3 Details of cable models to be used in the definition of the Upstream Coexistence Mask are addressed in Section 16.

9.2.4 The parameters a, b, AELE-MODE and the cable model representing the cable environment are themselves sufficient to define the in-band component of the Upstream Coexistence Mask. That Coexistence Mask is based on the UPBO PSD Mask formula defined in G.993.2 and Section 7.6 above.

> *NOTES:*
>
> 1. *Use of the same a and b parameters in equivalent bands ensures that CE at equivalent attenuations will transmit with equivalent PSD Masks and cause equivalent crosstalk.*

> *2. Use of the same AELE-MODE ensures that the method used by the equipment to estimate path attenuation is equivalent for each System sharing a Shared Cable Bundle.*

9.3 Vectored VDSL2 Deployment Class Systems that support UPBO

9.3.1 Other than for VDSL2 US0 which is always non-Vectored and does not support UPBO, there is no deemed sharing of Upstream Spectrum That Overlaps with a Vectored Deployment Class System.

9.3.2 Except where required by Part 1 to share spectrum with a non-Vectored Deployment Class System, the Provider of a VDSL2 Deployment Class System that has been Notified as Vectored is free to use any UPBO parameters and AELE-MODE that meet the requirements of International Standard upon which the Deployment Class is based, and the Template PSD Mask for the Deployment Class.

9.3.3 Details of cable models to be used in the definition of the Upstream Coexistence Mask are addressed in Section 16.

9.4 Determining Upstream Coexistence Mask based on UPBO

9.4.1 A Deployment Class System's Upstream Reference Coexistence Mask is based upon its Upstream Template PSD Mask. Deployment Class Systems which use UPBO reduce their Upstream transmit PSD levels using a function that depends upon the 'electrical length' (i.e. attenuation expressed at 1 MHz) between the CE and its DSLAM.

9.4.2 If the electrical length in a particular UPBO band equals or exceeds a certain 'reference length' for that UPBO band, the Upstream Coexistence Mask which applies at that electrical length is equal to the Upstream Reference Coexistence Mask in that UPBO band. Otherwise the Upstream Coexistence Mask which applies in that band should be calculated using the Upstream Reference Coexistence Mask in that band, the UPBO parameters for that band and the electrical length of the CE's location.

9.4.3 For any given CE location, it is necessary to determine the electrical length (represented by the variable kl_0) for use in the Upstream Coexistence Mask calculation. The electrical length should be calculated at specific CE locations using the path attenuation as a function of frequency [H(f)] for the cable path between the specific CE location and its DSLAM.

9.4.4 Using the end to end cable path attenuation H(f) described by Equation 8, the electrical length kl_0 should be calculated according to Equation 9 for a VDSL2 Deployment Class System, or Equation 10 for a G.fast Deployment Class System.

EQUATION 9
Length estimation method for VDSL2

Formulae	Notes
$kl_0 = min\left(\dfrac{H(f)}{\sqrt{f}}\right), \quad f \geq 1MHz$	f is expressed in MHz in this calculation H(f) is expressed in dB

EQUATION 10
Length estimation method for G.fast

Formulae	Notes
$kl_0 = average\left(\dfrac{H(f)}{\sqrt{f}}\right), \quad f \in used\ band\ tone\ frequencies$	f is expressed in MHz in this calculation H(f) is expressed in dB

> *NOTES:*
>
> *1. The value of kl_0 differs according to variations of cable topology, type and length.*
>
> *2. When calculating kl_0 for G.fast, the average is taken only across tones spanning the band that has been configured for potential use.*

EQUATION 11
Unadjusted Upstream Coexistence Mask

Formulae	Notes
$UCM(f)$ $= min\begin{cases} max\{kl_0, 1.8\} \times \sqrt{f} - (a + b\sqrt{f}) + 3.5, & f \in UPBO\ band \\ Template\ PSD(f) \end{cases}$	UCM is the unadjusted Upstream Coexistence Mask. It may require subsequent adjustment to accommodate Vectored Deployment Class Systems. Template PSD is the Template PSD of the System for which the UCM is being derived. f is expressed in MHz in this calculation

> *NOTE: Refer to Section 7.8 for details about PSD Mask adjustment which is required when generating Coexistence Masks for Vectored Deployment Class Systems.*

10 DETERMINING DEPLOYMENT CLASS SYSTEMS COMPLIANCE WITH UNACCEPTABLE INTERFERENCE

10.1 Deemed coexistence with a Non-Vectored Deployment Class System that supports UPBO in Spectrum That Overlaps

10.1.1   When two or more Systems share the same Shared Cable Bundle and Spectrum That Overlaps, the UPBO mechanism may be used to control Upstream interference between the different Systems.

This is possible because UPBO parameters a and b and the corresponding AELE-MODE setting control Upstream interference between CE of the same System located at different attenuation distances from the host DSLAM.

NOTE: UPBO is typically not required for a Deployment Class that does not and cannot share spectrum e.g. G.fast-SM (refer to Appendix B to Part 3).

10.1.2   In order for such interference control to be effective, the attenuation (specified at 3.75 MHz for VDSL2 Deployment Class Systems) between the lower priority Deployment Class System DSLAM External Interface Port and the entry point of the Shared Cable Bundle must not differ by greater than 0.5 dB from the corresponding attenuation between the Higher Priority Deployment Class System DSLAM External Interface Port and the entry point of the Shared Cable Bundle.

If this condition is satisfied, the requirement that the lower priority Deployment Class System must not cause Unacceptable Interference is met if the lower priority System uses the same a and b parameters and the same AELE-MODE as the Higher Priority Deployment Class System in Spectrum That Overlaps.

10.1.3   In accordance with 10.1.1, to avoid the potential proliferation of an excessively large set of differing a and b values, each description of a non-Vectored Deployment Class System in Part 3 of this Code includes a defined library of a and b values and guidance about how to choose the appropriate a and b values for a particular Deployment situation.

10.1.4   A prior Higher Priority Provider of a non-Vectored Deployment Class System must, when the sharing provisions of this code apply, use (or change to) one of the a and b parameter and AELE-MODE combinations in the applicable library of a and b values defined for that Deployment Class System.

10.1.5   Subsequent Deployment Class Systems must use the same a and b parameters as a prior Higher Priority Provider of a non-Vectored System when both Systems use Upstream Spectrum That Overlaps with one another.

11   DETERMINING NON-DEPLOYMENT-CLASS SYSTEM COMPLIANCE WITH UNACCEPTABLE INTERFERENCE

11.1   Requirements for Non-Deployment Class Systems

11.1.1   A System complies with the Unacceptable Interference requirements if it does not exceed both in-band and out-of-band Downstream and Upstream Coexistence Masks at the relevant reference points for all Higher Priority Deployment Class Systems Deployed to each Shared Cable Bundle that it traverses, including those Higher Priority Deployment Class Systems Deployed after the System was Deployed.

11.1.2   In determining compliance with Coexistence Masks, the following steps are required for each Notified Higher Priority Deployment Class System:

(a)   Obtain the Downstream Coexistence Mask from the description of the relevant Higher Priority Deployment Class System and adjust according to Equation 6 if the Higher Priority Deployment Class System is Notified as Vectored.

(b)   Determine the Limit PSD Mask (or the measured PSD under a range of conditions) for the Downstream transmit PSD of the DSLAM being examined for compliance. The Limit PSD Mask is calculated at the DSLAM's External Interface Port. (Refer to Section 11.1.3).

(c)   Refer that Limit PSD Mask to the Higher Priority Deployment Class System DSLAM location using the formula in Equation 4.

(d)   Compare the referred Limit PSD Mask with the Downstream Coexistence Mask for the Higher Priority Deployment Class System. If the Downstream Coexistence Mask is exceeded at any frequency by the referred Limit PSD Mask of the System being examined, the System being examined is non-compliant.

(e)   Determine the Upstream Coexistence Mask at each possible CE location using the process defined in Section 9, based on UPBO parameters a, b, and ELE_MODE defined for the Deployment Class System.

(f)   For UPBO based Higher Priority Deployment Class Systems, determine the Limit PSD Mask for the Upstream transmit PSD at all potential CE locations by calculating a finite series of PSD Masks based on different drop cable exit locations from the Shared Cable Bundle. Each drop cable exit location should be spaced no more than 0.5dB (at 3.75 MHz) apart from its neighbour. The masks are derived using any UPBO parameters defined for the Higher Priority Deployment Class System type. (Refer to Section 11.1.4).

(g)　At each of those possible CE locations, compare the Deployment Class System's Upstream Coexistence Mask against the corresponding Limit PSD Mask for the System being examined. If the Upstream Coexistence Mask is exceeded by the Limit PSD Mask for the System being examined at any frequency at any location, the System being examined is non-compliant.

11.1.3　Calculation of the Downstream Limit PSD Mask for the System being examined should be based on a relevant International Standard PSD Mask or should be based on a measurement by a certified laboratory of the maximum transmit PSD at each frequency across all relevant line conditions.

11.1.4　Calculation of the Upstream Limit PSD Mask for the System being examined should be based on a relevant International Standard PSD Mask and should be calculated using the proposed UPBO parameters at all possible CE locations. Alternatively, it may be based on a measurement by a certified laboratory of the maximum transmit PSD at each frequency and at each possible modem location across all relevant line conditions.

11.1.5　When referring a PSD Mask, the cable attenuations should be calculated by summing over all relevant cable segments, the product of the cable's per-kilometre frequency dependent attenuation expressed in dB, and the length of the specific cable expressed in kilometres.

11.1.6　If an accurate model of the attenuation characteristics of a cable that is not described in Section 16 is known at all relevant frequencies, that model may be used when calculating attenuations for the purpose of referring a PSD Mask, provided that the technical details of the model are made available upon request. If an accurate model of the attenuation characteristics of a cable is not known at all relevant frequencies, then cable characteristics for another cable of (i) identical conductor metal, and (ii) similar conductor gauge, and (iii) electrically equivalent conductor insulation material type, and (iv) identical conductor insulation thickness; may be used, otherwise CAD55 cable data should be used for the purpose of determining the Referred PSD Mask.

11.2　Near End Crosstalk

11.2.1　In meeting the fundamental requirements of Part 1 of this Code, the requirement not to cause Unacceptable Interference to a Deployment Class System of Higher Priority results in the following outcomes for TDD and FDD Systems. These are necessary consequences of the Code rules. When System combinations with characteristics listed below are assessed against the requirements of this Code they are found to be non-compliant.

11.2.2　A TDD System that operates in Spectrum That Overlaps with a Higher Priority Deployment Class System causes Unacceptable Interference.

11.2.3   A System that operates in Spectrum That Overlaps with a Higher Priority TDD Deployment Class System causes Unacceptable Interference.

NOTES:

1. G.fast adopts a TDD approach. VDSL2 and other Legacy System Technologies adopt an FDD approach. The two approaches are incompatible in Spectrum That Overlaps due to Excessive Near End Crosstalk between the different Systems.

2. Refer to additional information below about possible coexistence with and between TDD systems.

11.2.4   A System causes Unacceptable Interference if it transmits signals through a Shared Cable Bundle in Spectrum That Overlaps in the opposite direction to signals carrying Coded Data transmitted by a Higher Priority Deployment Class System.

NOTES:

1. This requires that if a Higher Priority Deployment Class System transmits at a particular frequency in a particular direction, another System cannot attempt to transmit Coded Data at the same frequency in the opposite direction in the same Shared Cable Bundle. When signals are transmitted in opposite directions through the same Shared Cable Bundle, the effect of Near End Crosstalk is heightened.

2. A situation where
(a) a Campus System makes use of a Shared Cable Bundle to serve another area of the Campus, and
(b) that Shared Cable Bundle is required by a System situated outside the Campus;
is an example where the Campus System risks causing Unacceptable Interference in Spectrum That Overlaps with the Network System. The Campus System must not use a Shared Cable Bundle in a direction opposite to that which may be required by a System situated outside the Campus.

11.3   Coexistence with and between TDD systems including G.fast systems

Shared Cable Bundles relevant to a System

11.3.1   A Shared Cable Bundle relevant to a system comprises:

(a)   Cables that are members of the Cable Footprint Of A System; and

(b)   Cables that are parallel to any cable in the Cable Footprint Of A System.

11.3.2   Two cables are parallel if at any cross-sectional position along both cables, they are running in parallel directions either in the same duct, the same cable tray or otherwise along the same

locally proximate cable pathway, and neither of the two cables are correctly earthed screened cables.

> *NOTE: As an example, particularly in a building riser but also potentially at any location, other cables may run parallel with those cables comprising the Cable Footprint Of A System. These additional parallel cables become part of the Shared Cable Bundles relevant to that System.*

The TDD System overlapping footprint rule

11.3.3   A System Provider shall not deploy an equal or lower priority System (either FDD or TDD) in the same Shared Cable Bundle as an equal or higher priority TDD system where both Systems use overlapping spectrum.

> *NOTES:*
>
> *1. The use of overlapping spectrum by both Systems in this scenario will cause Unacceptable Interference to the equal or higher priority TDD system.*
>
> *2. A consequence of the TDD System overlapping footprint rule is that the Shared Cable Bundles within the Cable Footprint Of A System, where the higher Priority System uses TDD, must be mutually exclusive with other systems sharing spectrum.*
>
> *2. A VDSL2 Deployment Class System and a G.fast-SM Deployment Class System do not share spectrum because the G.fast-SM Deployment Class System requires masking of frequencies used by the VDSL2 Deployment Class System. This means the TDD system overlapping footprint rule does not prevent any of the VDSL2 deployment classes sharing the same cable bundles as a G.fast-SM system.*

The joining cable section rule

11.3.4   An equal or lower priority system operating in one cable footprint area and using spectrum shared with an equal or higher priority TDD system operating in an adjacent cable footprint area which is separated from the equal or lower priority system's cable footprint area by a Joining Cable Section, causes Unacceptable Interference to the equal or higher priority TDD system if the attenuation of the Joining Cable Section is less than 0.4dB at any frequencies in spectrum that is shared with the equal or higher priority TDD system.

> *NOTES:*
>
> *1. 0.4 dB is equivalent to approximately 4 m of CPFUT40 at 20 MHz and similar to the typical length of riser cable separating adjacent floors in a multi-storey building.*
>
> *3. Any cable may either touch, or traverse, or touch and traverse, or neither touch nor traverse; a Shared Cable Bundle.*

Demonstrating spectral compatibility with a TDD system

11.3.5   Under normal deployment circumstances involving an equal or higher priority TDD system, compliance with this Code involves deploying and operating both the equal or higher priority system and the equal or lower priority system in accordance with both the Code's rules and with the respective Deployment Class System requirements. When a Deployment Class System is operated in accordance with all rules and the respective Deployment Class System requirements, the operator of the Deployment Class System avoids the necessity to undertake the coexistence calculations which would otherwise be necessary to demonstrate compliance with the Code.

11.3.6   Either:

(a)   planning to deploy a TDD non-deployment class system; or

(b)   preparing a proposal for a new kind of TDD deployment class system,

requires both:

(c)   the compliance calculations; and

(d)   demonstration of compliance and coexistence.

12   SYSTEM NOTIFICATION

12.1   Introduction

12.1.1   The purpose of this section is to describe the information which System Providers are required to notify to other Providers wishing to share Shared Cable Bundles. Notification is necessary to enable other System Providers to efficiently and harmoniously coexist in the same Shared Cable Bundles.

12.1.2   Details about the notification protocol and the required information format are described in section 13.

12.1.3   When notifying a Building or Campus System, a Provider must make the information described in the paragraphs of section 12 available for access by other Providers, Communications Alliance, and the ACMA.

12.2   Information to be provided by System Providers

12.2.1   The following information about a System's design, configuration and situation must be made available in order to be considered Notified:

12.2.1.1   The footprint of end users served by the System.

The footprint information must be Notified in a way that allows another Provider to determine the location of any relevant Shared Cable Bundle.

(a)   When there is more than one building in a Campus, the Notified System footprint information must be broken down to specific buildings.

(b)   For Systems that cover a smaller footprint than the entirety of a building, the Notified System footprint information must be broken down to floors or horizontal sectors in a building. The smallest unit of coverage for a building is therefore a floor or sector.

(c)   For every System, the Notified System information should indicate the tail attenuation from the External Interface Port of the DSLAM to the network end of the Shared Cable Bundles served by that DSLAM, expressed as dB at 3.75 MHz for VDSL2 Deployment Classes. Generally, this will be the attenuation of the cable path between the DSLAM and the MDF plus the attenuation of the longest potential jumper cable on the MDF.

12.2.1.2   The Deployment Class used by the System.

12.2.1.3 Other relevant operational parameters for the System including:

(a) The Deployment Class if it is a Deployment Class System.

(b) The technology used by the System and relevant spectral information.

(c) The Downstream DPBO PSD Mask setting in the Legacy System band below 2.208 MHz.

(d) The UPBO parameters a and b.

(e) The AELE-MODE applied on the System and to be used for calculation of kl0 in the UPBO.

12.2.1.4 Whether the Provider has been forced by the Sharing Resolution Process to change to Deployment Class System based on a spectral split, under the rules of Part 1 Clause 6.3.

12.2.2 System Providers must retain:

12.2.2.1 Calculations or evidence of processes demonstrating that applied DPBO PSD Mask designs protect Legacy Systems; and

12.2.2.2 Evidence that where the System uses a technology that supports UPBO it meets one of the following requirements:

(a) If the System is Notified as non-Vectored and shares Upstream Spectrum that Overlaps with a Higher Priority System, evidence that the System has used the standard UPBO parameters and AELE-MODE specified by any Higher Priority System using those bands.

(b) If the System is Notified as non-Vectored, and is the highest priority, that the a and b parameters in use for that Deployment are the appropriate choice from the specified set of UPBO parameters in Table 3 of Part 3.

12.2.3 Information to be provided by a Network Provider of a Deployment Class System

12.2.3.1 For cabling within the access network, where the System is a Network System, the Network Provider should, on request, notify or provide a loop trace stating in position order the cable type and length of each segment of cable that makes up that part of the Tail Cable between the network DSLAM and the NBP to another Provider participating in the System Notification Scheme, Communications Alliance, or the ACMA.

> *NOTE: Section 16 describes methods for calculation of cable attenuations based upon cable type and segment length.*

12.2.4 **Information to be provided by a Building Provider of a Deployment Class System**

12.2.4.1 For cabling within the Building or Campus, the first building Provider of a Deployment Class System should identify and make available on request the cable architecture covering lengths and cable types within the Building or Campus, including all potentially Shared Cable Bundles.

> *NOTES:*
>
> *1. The Network Provider does not need to do this for each building in the footprint of a network FTTN node.*
>
> *2. Section 16 describes methods for calculation of cable attenuations based upon cable type and segment length.*

12.2.5 **Cable information to be provided by all System Providers**

12.2.5.1 Cable length should be determined as accurately as feasible in accordance with section 8.6.6 and that length used as the basis for deriving the cable's attenuation function from the applicable cable model.

Shared Cable Bundle records associated with the plant should not be assumed to be accurate.

> *NOTE: Providing this information is necessary to avoid delay in facilitating the harmonious coexistence of other Systems with a Deployment Class System.*

12.2.5.2 The cable type used for the purpose of ascertaining Full Coverage and for the other purposes of this Code must be determined as follows, in descending order of preference:

(a) If a Higher Priority or Prior System has been Deployed, the Provider of that Higher Priority or Prior System must notify cable details in accordance with this Code or provide details upon request, and the corresponding cable model(s) should be used; otherwise

(b) If a Shared Cable Bundle section or Tail Cable is entirely of the Cat5 or Cat6 type, the Cat5 cable model must be used for that Shared Cable Bundle section or Tail Cable and must not be used otherwise; otherwise

  (c) If the cable type that has been deployed in a building corresponds to a cable type described in section 16, and the corresponding cable model is valid for all relevant frequencies, then that cable model must be used; otherwise

  (d) If the Building Provider has an accurate model of the attenuation characteristics of a Shared Cable Bundle section or Tail Cable at all relevant frequencies, that model may be used; otherwise

  (e) If the cable type that has been deployed does not correspond to a cable type described in section 16, and no cable model is available for that type of cable, the default CAD55 cable type must be used.

12.2.5.3 If a Building Provider uses a cable model that is not described in section 16, technical details of the cable model must be made available upon request.

13 SYSTEM NOTIFICATION SCHEME

13.1 Introduction

13.1.1 The purpose of this section is to define a protocol and information formats to simplify the procedure for notification and minimise the interaction between Providers. Notification is necessary to enable other System Providers to efficiently and harmoniously coexist in the same Shared Cable Bundles.

> *NOTE: the intention of the protocol and file formats described in this section is that, according to Provider preference, many aspects of the System Notification Scheme can be automated so that the manual aspects of implementing the scheme may be minimised.*
>
> *Although the protocol and file formats have been designed with automation in mind, the Code does not preclude Providers that prefer manual processes from participating in the System Notification Scheme.*

13.1.2 The notification scheme described in this section is a kind of distributed data base. Each System Provider publishes notifications about their own Systems, and takes notice of the notifications published by other System Providers about their Systems.

> *NOTE: Notifications may describe a new (proposed) System, or may provide additional information about a previously Notified System, or in the case where errors need to be corrected, may supersede previously Notified information.*

13.1.3 System Providers must configure and operate their Systems in accordance with the coexistence principles outlined in Part 1 of this Code, and on the basis of information other System Providers have Notified.

13.1.4 Up to date notification files should be readily accessible to participants in the notification scheme via the Internet.

13.1.5 Other than for the purpose of infrequent site maintenance or because of an Internet fault, Notified information should be available to be accessed at any time.

13.1.6 Participants are deemed to have Notified in accordance with this Code if done so in accordance with this section.

13.2   Participating in the System notification scheme

13.2.1   Communications Alliance will manage a List of Participants in the System notification scheme. System Providers participating in the notification scheme should apply to Communications Alliance to be included in a published List of Participants, furnishing the information described in this section to be made available to other participants in the System notification scheme.

13.2.1.1   System Providers may specify a publicly accessible URL at which their most up to date notification information may be accessed.

13.2.1.2   System Providers must specify a regularly checked email address to which announcements from other System Providers regarding an update to the other Provider's System Notification File should be sent. The format of these emails is described in Section 13.6.

13.2.1.3   System Providers must specify a regularly checked email address to which other correspondence may be sent.

13.2.1.4   System Providers must indicate a preference either to receive email notifications from other System Providers:

(a)   'filtered': only when the other System Provider makes an addition or change to their System Notification File that is in a common Shared Cable Bundle and may affect this Provider, or

(b)   'any': whenever the other System Provider makes any change or addition to their System Notification File.

NOTE: Providers with a smaller number of Systems may prefer the first option because it will limit the email traffic to that subset which directly affects them. Providers with a larger number of Systems may prefer the second.

13.2.2   Communications Alliance will publish the list of participants, their URLs and email addresses in the System notifications scheme on their web site at https://www.commsalliance.com.au/Documents/Industry-Lists/

13.2.3   Communications Alliance will update the list of participants, the participant URLs and contact email information from time to time as participants join or leave the scheme.

NOTE: It is important that participants have a process for regularly checking the contact details published by Communications Alliance in order to respond to changes.

13.2.4   System Providers may advise Communications Alliance of changes in their publicly accessible URL or other information from time to time. Changes are expected to be rare and infrequent.

13.2.5   System Providers may publish System notification information on their own web site at the URL that appears in the Communications Alliance List of Participants file.

13.2.6   System Providers must maintain the currency of the notification information on their own web site in accordance with:

(a)   the roll out of new Systems;

(b)   changes in System configuration or other relevant System information, for example but not limited to changes required for harmonious coexistence with other Systems;

(c)   responding to other Providers' notifications, such as for the purpose of notifying decisions as a part of the Sharing Resolution Process; and

(d)   corrections to previous notification errors; and

(e)   promptly withdraw redundant notifications and in any case, within five business days of any decision to not proceed with the New or Upgraded System.

13.2.7   A System Provider may implement access restrictions with respect to the URL at which its Notification information may be accessed, including credential-based access and firewall-rules restrictions, to protect the confidentiality of its Notified information.

13.2.8   To the extent a System Provider (Notifying System Provider) implements such access restrictions:

(a) Subject to (b) below, the Notifying System Provider will, upon written request from another Subscribed System Provider (Accessing System Provider), provide the Accessing System Provider with any information required to access the Notified information (Access Information); and

(b) The provision of any Access Information by the Notifying System Provider may be conditional upon the Accessing System Provider first agreeing to be bound by an undertaking in favour of the Notifying System Provider with respect to the relevant Notified Information on the terms of paragraph 7.3.4 of part 1 of this Code.

13.2.9   A Provider must not Notify a New or Upgraded System unless there is a reasonable basis to proceed with the rollout of the New or Upgraded System that is the subject of the Notification, acting in good faith.

13.3   The List of Participants file

13.3.1   The list of participants will be in a CSV format file in accordance with Section 13.7.

> *NOTES:*
>
> *1. The CSV format has been chosen because if required, it can be managed in a consistent and straightforward-to-automate manner.*
>
> *2. The CSV format facilitates individual Provider choice whether to generate and process these emails automatically or manually according to the individual business needs and priorities of each Provider.*

13.3.2   The contents of the first row in the List of Participants file is unconstrained and should be ignored by any automated parsing processes. The intended purpose of the first row is to include column headings. The actual text for the column headings is not constrained by this Code.

13.3.3   Each row other than the first row in the List of Participants file will represent one participant in the System notification scheme.

13.3.4   At any time, Communications Alliance may change the order in which participants are listed in the List of Participants file.

13.3.5   Table 11 outlines the format and purpose of each field in the CSV file.

TABLE 11
Purpose of fields in the List of Participants file

CSV field ID (field number)	Purpose of field
1	System Provider's name
2	ABN
3	System Provider's Business Address
4	Mailbox / email address for advising changes to other Providers' System Notification files Other System Providers should use this mailbox to inform the System Provider about updates to the other System Provider's System notification files, in accordance with this Provider's preference identified in field 7. The 'received' timestamp on emails received in this mailbox may be used as an indication of another Provider's System Notification File date, but this means of verification is not reliable unless verified against the received timestamps of all other System Providers that received similar notification.
5	Mailbox / email address for other correspondence Other System Providers may use this mailbox to correspond with this System Provider for other purposes associated with the operation of Systems in accordance with this Code. Each organisation must be responsible for ensuring that a delegate is available on all working days to manage correspondence directed at this mailbox.
6	URL of the System Notification File
7	Automated Notification Preference This field holds one of two options represented by the characters 'A' and 'F'. The character 'A' indicates that this Provider requests automated notifications from other Providers whenever the other Provider makes *any* change to their System Notification File. The character 'F' indicates that this Provider requests *filtered* notifications from other Providers, advising only when the other Provider has made a change or introduced a new System that is in a common Shared Cable Bundle and may affect this Provider.

13.4   The System Notification File

13.4.1   Providers may publish a System Notification File containing the notifiable information for every System which that Provider wishes to Notify.

> *NOTE: Notifications for all of a Provider's Systems should be included in the same System Notification File using different rows to represent each System notification.*

13.4.2   The System Notification File may be updated from time to time as required, but should not be updated more frequently than once daily.

13.4.3   The System Notification File must be in a CSV format file in accordance with Section 13.7.

13.4.4   System Providers may publish the System Notification File at the publicly accessible URL nominated in the List of Participants file published by Communications Alliance.

13.4.5   Table 12 outlines the format to be used for the first line (the first row) of the System Notification File which contains the publication date and version number for the relevant iteration of the System notification file. These two fields together uniquely identify the version of a particular System Notification File.

13.4.6   System Notification Files with a higher iteration number supersede versions with a lower iteration number.

TABLE 12

System Notification File – content of fields for Row 1

CSV field ID (field number)	Description of data field in row 1
1	System Notification File Iteration Number Positive Integer representing the System Provider's iteration number for this version of the System Notification File. The initial version of the System Notification File must be called (the single digit) '1'. Subsequent iterations of the System Notification File must be numbered consecutively in a monotonically increasing sequence of integers.
2	Date of publication of this iteration of the System Notification File Format: YYYY-MM-DD (ten character sequence of digits and '-' characters) This date represents the date on which this iteration of the file is claimed to have been Notified (Australian Eastern Standard Time, [GMT +10]). The claimed date of publication of this iteration of the file must not be earlier than either (a) the 'sent' timestamp of the notification email advising of the publication of this iteration of the file, or (b) the time at which this iteration of the file first becomes accessible via the Internet at its URL.

13.4.7 The contents of the second row in the System Notification file is unconstrained and should be ignored by any automated parsing processes. The intended purpose of the second row is to include column headings. The actual text for the column headings is not constrained by this Code.

13.4.8 Unambiguous interpretation of the System Notification File is contingent on Providers dividing the Notification of one System across multiple rows of the System Notification File therefore, commencing with row 3 of the System Notification File and for every subsequent row, each row should represent:

(a) one and only one System; and

(b) one and only one Technology type; and

(c) one and only one Deployment Class.

> NOTE: For example a System which simultaneously supports VDSL2 and G.fast should be represented by one or more rows describing its VDSL2 coverage, and one or more additional rows describing its G.fast coverage.

13.4.9 Where more than one row is used to describe a unique combination of {System identity, technology, Deployment Class}, the coverage area described by each such row must not overlap

with the coverage area described by another row for the same {System identity, technology, Deployment Class}.

> *NOTES:*
>
> *1. If a single System supports two or more technology types, then separate rows should be defined to represent each technology type. For example, this facilitates unambiguous notification of different coverage areas for VDSL2 and G.fast originating from the same System.*
>
> *2. If a Provider has one System covering two or more buildings in a Campus, for example a VDSL2 Building System which feeds end users in a different building, then different rows should be used to define each building covered by the Campus System.*

13.4.10 Providers may change the order in which Systems are listed in the System Notification File at any time without otherwise affecting the interpretation or priority of the notification.

13.4.11 Any date in a System Notification File which is earlier than the date of Code Registration may be assumed to be the same as the Date of Code Registration.

13.4.12 Table 13 outlines the format and purpose of each field in each subsequent line of the System Notification File.

TABLE 13

System Notification File – content of fields for Row 3 and subsequent rows

CSV field ID (field number)	Description of data field in row 3 and subsequent rows
1	Reference ID Field representing the System owner's reference identifier for this System. This is the reference to be used for all correspondence about the System. The field may contain letters and numbers only. The field may not contain spaces or other characters. Once issued, the reference ID should not be subsequently changed. The same Reference ID may be used on different rows in the System Notification File to represent (a) different non-overlapping coverage areas associated with the same System, (b) different technologies supported by the same System, (c) different Deployment Classes supported by the same System.
2	Priority Date Format: YYYY-MM-DD (ten character sequence of digits and '-' characters) This date is initially set to the date on which the record first appears in this database (Australian Eastern Standard Time, [GMT +10]). The Priority Date must match the date in field 2 of the first row of the file that contained the first valid notification. If the System notification is invalid in the current iteration of the System Notification File, the value in this field must be updated in subsequent iterations of the System Notification File to reflect the date on which a valid notification first appears, or as agreed with all other affected System Providers.
3	Last record modification date Format: YYYY-MM-DD (ten character sequence of digits and '-' characters) This date is initially set to the date on which the record first appears in this database (Australian Eastern Standard Time, [GMT +10]). This date in this field reflects the date in row 1 field 2 of the System Notification File in which this record was last changed. If the latest version of this record is retracted, the date in this field may revert to the value which was in this field for the most recent valid version of this record.

CSV field ID (field number)	Description of data field in row 3 and subsequent rows
4	Date of first operation (the 'First Operation Time') Format: YYYY-MM-DD (ten character sequence of digits and '-' characters) This date is initially set to the date six months after the Priority Date, and may be subsequently changed to an earlier or later date in accordance with this Code. Failure to have Deployed the System and have it ready to operate and provide services from the indicated date invalidates the record other than with a valid reason recorded in field 29 and acceptable under the Code. Evidence to support a valid change to a later Operation Time must be provided on demand, or the claimed Priority Date will be invalid. After a System has entered operation for the first time, the value in this field should remain the same thereafter.
5	Either (a) the Initiator's Date Of Operation, or (b) the respondent's or incumbent's Make Ready Date Format: YYYY-MM-DD (ten character sequence of digits and '-' characters) The date in this field is only meaningful in relation to the most recent Sharing Resolution Process applying to this System. The Initiator uses this field to notify the proposed Date Of Operation. Responders and Incumbents use this field to notify the proposed Make Ready Date.
6	Highest Attenuation Path Status Single character: 'F' (meets highest attenuation path test of the Full Coverage requirements) or 'N' (either (a) this System is a Deployment Class System which does not meet the highest attenuation path test for Full Coverage requirements, or (b) this System is a Non-Deployment Class System). In order to specify 'F' in this field, both (a) the System design must be a Deployment Class System that (b) satisfies the requirements of Table 4 or 5 of Part 1 of this Code for the highest attenuation line which could potentially be served from this System. Mistakes in this field mean the claimed Priority Date will be invalid.

CSV field ID (field number)	Description of data field in row 3 and subsequent rows
7	Available Port Capacity Single character: 'A' (available port capacity), or 'N' (no available port capacity). 'A' represents a System that has available capacity for immediate connection of additional end users, should demand eventuate. 'N' represents a System that does not currently have capacity to immediately connect an additional end user, should demand eventuate. When a System is reaches its First Operation Time, this field should contain 'A' indicating ports are available for immediate connection of end users, and may continue to contain the value 'A' for as long as spare working ports, Tail Cable and cross connection capacity are available for the connection of additional services, should demand eventuate. The value in this field should be changed to 'N' no later than [90] days from the first date on which demand for a service could not be satisfied. Failure to update this field within the specified timeframe will invalidate the claimed Priority Date. Systems which do not satisfy the requirements for indicating 'A' in this field cannot have Full Coverage status.
8	G-NAF Unique Persistent Identifier (G-NAF PID) The 14-character alphanumeric string that uniquely identifies the G-NAF primary address In the case that a G-NAF does not exist, this field should be filled with the capitalised 7-character string MISSING. In this case, fields 10 and 11 assume the full purpose of this field. Mistakes in this field may invalidate the record meaning the claimed Priority Date will be invalid for this System. The only change to this field that does not invalidate a claim to a former notification date is when a change is introduced into the national G-NAF database that affects the G-NAF PID, provided that change is incorporated into this record within [90] days of the change first appearing in the national database.
9	Former G-NAF PID (or blank) In the case field 8 must be updated due to a change in the national G-NAF database that affects the G-NAF-PID, this field reflects the former contents of field 8. The field is blank otherwise.

CSV field ID (field number)	Description of data field in row 3 and subsequent rows
10	Longitude of the DSLAM This field is used as a clarification of the G-NAF PID in case of ambiguity and should always be filled with valid information regardless of whether the G-NAF PID requires clarification or not. The point represented by the longitude/latitude values contained in fields 10 and 11 should unambiguously geo-locate the building or structure in which the DSLAM is installed. The longitude should be expressed as a decimal fraction with a precision of at least five decimal places (a precision of approximately 1m). Mistakes in this field invalidate the record meaning the claimed Priority Date will be invalid when the G-NAF PID is ambiguous or MISSING. In the event of conflict between the G-NAF PID and this field, the G-NAF PID takes priority.
11	Latitude of the DSLAM This field is used as a clarification of the G-NAF PID in case of ambiguity and should always be filled with valid information regardless of whether the G-NAF PID requires clarification or not. The point represented by the longitude/latitude values contained in fields 10 and 11 should unambiguously geo-locate the building or structure in which the DSLAM is installed. The latitude should be expressed as a decimal fraction with a precision of at least five decimal places (a precision of approximately 1m). Mistakes in this field invalidate the record meaning the claimed Priority Date will be invalid when the G-NAF PID is ambiguous or MISSING. In the event of conflict between the G-NAF PID and this field, the G-NAF PID takes priority.
12	Property street address This field is used as a clarification if the G-NAF PID, in case of ambiguity. Valid notifications should not depend upon this field if a valid and unambiguous G-NAF unique persistent identifier exists for the primary address of the property or building the currently published G-NAF database. The comma character frequently appears in street addresses, and where used, requires this field to be encapsulated by double quote characters as outlined in the CSV file format specification outlined in section 13.7.

CSV field ID (field number)	Description of data field in row 3 and subsequent rows
13	Category of System serving this GNAF Single character: N (Network System) or B (Building System), P (partial Building System) or C (Campus System) 'N' indicates the System is a Network System such as a FTTN Deployment serving the area via network cabling. 'B' indicates the System is a Building System that may only be connected to a premises or location within the building in which the System DSLAM is installed. 'P' indicates the System covers a defined part of a building. This category includes a DPU serving one or a small number of floors of the same building. When a Provider has two or more Systems of the same technology type in a building, they are not 'P' Systems unless their coverage areas are mutually exclusive. 'C' is a Campus System and includes every System which is not an 'N', 'B' or 'P' System. Mistakes in this field invalidate the record meaning the claimed Priority Date will be invalid.
14	Building identifier (or blank) Free text field that is specified when field 13 (Category Of System) is 'C', and may optionally be used for other System categories. This field is used to identify the building containing the Shared Cable Bundle(s). It may contain the name or number or identifier of the building. If the set of Shared Cable Bundle(s) which may be used by a particular System cover more than a single building, separate records should be created for each of the buildings.
15	Floor identifier (or blank) Specified when System coverage is 'P'. May include a range of floors or areas in the form 'n-m' (where n and m are floor or area identifiers). This field is used to identify the floor or range of floors of a building containing the Shared Cable Bundle(s) applicable to this System. To the extent that it is feasible and practical, the floor or area identifiers should correspond with the naming convention used at the property itself, for example the naming convention as used in the lifts or fire escape doors. Mistakes in this field invalidate the record meaning the claimed Priority Date will be invalid.
16	Related Shared Cable Bundle records (or blank) Specified when System coverage is 'P'. A space-separated list of Reference IDs associated with this record. All of the entries in the space separated list represent the entirety of the Shared Cable Bundle(s) applicable to this System.

CSV field ID (field number)	Description of data field in row 3 and subsequent rows
17	Deployment Class type The values in this field are to correspond with the short-name Deployment Class Systems defined in the Code, for example V811V. Non-Deployment Class Systems are to be represented by the four letters NDCS for 'Non-Deployment Class System'. Mistakes in this field invalidate the record meaning the claimed Priority Date will be invalid.
18	Non-Deployment Class System type (or blank) If the System is a Non-Deployment Class System, this free-text field describes the technology standard or type, for example VDSL2, G.fast, G.HN, 1000BaseT, etc.
19	Non-Deployment Class System lower frequency (or blank) If the System is a Non-Deployment Class System, this integer field defines the lower frequency that may potentially be used to carry Coded Data by the Non-Deployment Class System, and is expressed in Hz. For tone based Systems such as ADSL, VDSL2 or G.fast, this value will be the centre frequency of the lowest configured usable tone.
20	Non-Deployment Class System upper frequency (or blank) If the System is a Non-Deployment Class System, this integer field defines the upper frequency that may potentially be used to carry Coded Data by the Non-Deployment Class System, and is expressed in Hz. For tone based Systems such as ADSL, VDSL2 or G.fast, this value will be the centre frequency of the highest configured usable tone.
21	Nominal attenuation of the UPBO setting Used with Deployment Class Systems for which this Code requires UPBO information to be shared in order to facilitate harmonious coexistence in the same spectrum; or blank otherwise. This field refers to nominal attenuation of the applicable UPBO shaper used by this System. The nominal attenuation must be taken from the applicable library of UPBO shapers specified in part 3 of this Code and is expressed as an integer. If a UPBO value is required but the value of the UPBO attenuation is not yet known, the field should be filled with the two characters 'NA'. The record should be updated with valid information prior to activation of the first service.

CSV field ID (field number)	Description of data field in row 3 and subsequent rows
22	UPBO AELE mode Used with Deployment Class Systems for which this Code requires UPBO information to be shared in order to facilitate harmonious coexistence in the same spectrum; or blank otherwise. The field refers to the AELE mode that is being used by the System, as described in G.993.2 and is represented by an integer between 0 and 3. If UPBO is required but the AELE-mode is not yet known, the field should be filled with the two characters 'NA'. The record should be updated with valid information prior to activation of the first service.
23	Nominal attenuation of a DPBO PSD Mask applied to protect Legacy Systems and VDSL2 Systems below 2.208 MHz Used with Deployment Class Systems for which this Code requires a DPBO PSD Mask to have been used to protect a Legacy System or VDSL2 System in spectrum below 2.208 MHz; or blank otherwise. This field refers to nominal attenuation of the applicable DPBO PSD Mask used by this System. The nominal attenuation must be taken from the applicable library of DPBO PSD Masks specified in section 6.3 and is expressed as an integer. If a DPBO PSD Mask value is required but the value of the DPBO PSD Mask attenuation is not yet known, the field should be filled with the two characters 'NA'. The record should be updated with valid information prior to activation of the first service.

CSV field ID (field number)	Description of data field in row 3 and subsequent rows

24	Tail Cable trace between System (DSLAM end) and start of Shared Cable Bundle.
	
	This text field specifies a string that represents the cable trace of each cable segment connecting the DSLAM and the start of the Shared Cable Bundle.
	
	The cable trace consists of a sequence of one or more of the following (a) a cable name as described in Section 16, (b) a space, (c) a segment length expressed in metres or a decimal fraction of metres, and when there are two or more cable segments in sequence (d) a '|' separation character (hexadecimal 8 bit value 0x7c).
	
	Jumper segments within an IDF or MDF should be included in the cable trace using the designation 'jumper' and a nominal length representative of the maximum expected jumper length in that situation. The need to represent jumper segments is in accordance with Section 12.2.1.1. Jumper attenuation may be modelled using the cad55 cable model.
	
	As examples, a cable trace consisting of a single 5.3m length of cad55 would be represented by the sequence
	
	`cad55 5.3`
	
	A cable trace comprising 30m of cptie, 18m of cpfut40, 35m of peiut40 and an MDF jumper link of a maximum length 6m would be represented by the sequence
	
	`cptie 30|cpfut40 35|peiut40 35|jumper 6`
	
	If the cable trace is not yet known, the field should be filled with the two characters 'NA'. The record should be updated with valid information prior to activation of the first service.

25	Trace of the longest cable run from start of Shared Cable Bundle to the most distant CE This text field specifies a string that represents the cable trace of the longest cable run from the entry to the Shared Cable Bundle to the furthest end of the Shared Cable Bundle. As for field 20, the cable trace consists of a sequence of one or more of the following (a) a cable name as described in Section 16,, (b) a space, (c) a segment length expressed in metres or a decimal fraction of metres, and when there are two or more cable segments in sequence (d) a '|' separation character (hexadecimal 8 bit value 0x7c). The drop segment should be included in the cable trace using the designation 'drop' and the nominal length of 20m, in accordance with section 8.4.1. It should be modelled using the cad55 cable model. If the cable trace is not yet known, the field should be filled with the two characters 'NA'. The record should be updated with valid information prior to activation of the first service.

CSV field ID (field number)	Description of data field in row 3 and subsequent rows
26	Claim of Exclusive agreement The eight character string 'EXCLUSIVE' indicates that the cable owner has come to an exclusive agreement with the System Provider, which the System Provider asserts limits rights of other System Providers from accessing Shared Cable Bundles. The System Provider must provide full details of the exclusive agreement upon request to support the claim to exclusivity. If there are no claims to exclusivity, the field should be left blank.
27	Name of known Coexisting System Providers If any Coexisting System Providers are known to have an overlapping footprint with this System, the name of that Provider should be included in this field; or blank otherwise. When there is more than one known Coexisting System Provider, the entire field may be encapsulated in double quotes and the individual Provider names may be separated by commas. The names expressed in this field should correspond with the names used in field 1 of the List of Participants file. If the name in the List of Participants file is updated, the name used in this field should correspondingly be updated. When a System Provider recognises its name in another System Provider's System Notification File, this should be a trigger to perform an assessment for coexistence compatibility, and to initiate a System Upgrade, System change, and subsequent responses etc.
28	List of known Coexisting System Providers whose Systems may need to change under the Sharing Resolution Process. If any Coexisting System Providers are known to have an overlapping footprint with this System, and if any of those Coexisting System Providers are required to change their current configuration in order to harmoniously coexist with this System, then the names of those Providers should be included in this field; or blank otherwise. When there is more than one known Coexisting System Provider, the entire field may be encapsulated in double quotes and the individual Provider names may be separated by commas. The names expressed in this field should correspond with the names used in field 1 of the List of Participants file. If the name in the List of Participants file is updated, the name used in this field should correspondingly be updated. After the other Provider(s) have changed their System(s) to harmoniously coexist with this System, their name may be removed from this field.

CSV field ID (field number)	Description of data field in row 3 and subsequent rows
29	Reason for deferral of Operation Time (used in conjunction with fields 4 or 5) The five character string 'POWER' indicates that service availability has been frustrated by the non-availability of a connection to the power network. The 8 character string 'APPROVAL' indicates that service availability has been frustrated by an approval of a relevant authority or the building owner. No other valid reasons for extending service availability deadlines are yet defined. The field should otherwise be left blank. This field has the effect of extending the date that a System is required to be ready to connect and provide services.
30	System subject to a 'live' cooperation process The eleven character string 'COOPERATION' indicates that the System is subject to an active cooperation process, or is blank otherwise. The field is used to identify Systems covering a Shared Cable Bundle which is subject to an active cooperation process, because only a single cooperation process is allowed at one time for a particular Shared Cable Bundle. The field is intended to be set to the term 'COOPERATION' following notification and the subsequent one month response period if and only if one or more responders have responded. At that time, a Cooperation process is activated and this field is used to flag that. The field must be promptly cleared at the conclusion of the cooperation period.

13.4.13   The System Notification File is typically expected to be updated weekly as an infrastructure Provider progresses its roll out, but may potentially be updated more frequently according to the preference of each System Provider.

13.4.14   The System Notification File must not be updated more frequently than once daily.

13.4.15   It is in the interests of each System Provider to maintain current awareness of the activities of other System Providers that may affect them and to respond in a timely manner.

13.4.15.1 System Providers engaged in active roll out should check the status of each other System Provider's System Notification File daily, and be working from and responding to the most recent versions of each other Provider's System Notification File.

13.4.15.2 System Providers not engaged in active roll out should check for email advice from other System Providers daily, which will indicate when another Provider has

made a change to their System Notification File that affects this Provider.

13.4.16　The System Notification File will only list building and Campus System coverage, and will not list single dwelling unit and non-addressable premises coverage.

13.5　Notification Dates

13.5.1　The notification date for Systems declared in rows 3 or subsequent in the System Notification File is the latter of the dates upon which either:

(a)　that System's record is deemed to have been first Notified, or

(b)　a substantive correction (that affects others ability to coexist) to that System's record is deemed to have been Notified.

> *NOTE: This is intended to apply to fields in Table 13 identified as fields that may invalidate a record.*

(c)　A valid 'New Notification' is issued for the System.

13.5.2　The notification date is invalid if the corresponding record is invalid.

13.5.3　The Priority Date is assigned based on the notification date and the rules of Part 1.　The Priority Date may only be retrospectively claimed:

(a)　Within the first two months after code registration as specified in Part 1, or

(b)　Following a System Upgrade as specified in Part 1, or

(c)　 with agreement of all other affected service Providers.

> *NOTES:*
>
> *1. The Provider of a System whose records have been substantively corrected may only retain the original notification date with the agreement of all other System Providers serving overlapping footprint. In the case agreement is not reached, the notification date of the System whose records have been corrected becomes the date the corrected notifications were published.*
>
> *2. This aspect of the protocol is intended to ensure that parties that have made design and investment decisions in good faith are not disadvantaged by the mistakes or errors of other parties.*

13.5.4　If an exclusive agreement between a cable owner and a Provider is cancelled or expires or is legally invalid, the details of

the exclusive agreement must be removed promptly from that System's record.

> *NOTE: This aspect of the protocol is intended to facilitate efficient and fair competition.*

13.6   Announcement emails

13.6.1   Each time the System Notification File is changed or updated, an announcement email must be sent to each of the addresses contained in field 4 of the List of Participants file that have indicated an 'A' preference in field 7.

13.6.2   Announcement emails must be sent to addresses contained in field 4 of the List of Participants file that have indicated an 'F' preference in field 7 only when a change is introduced to the System Notification File that corresponds to a common Shared Cable Bundle and affects that other Provider.

> *NOTE: Other participants' System Notification Files may be accessed via the URLs listed in field 6 of the List of Participants file.*

13.6.3   The 'Subject' line in an announcement email must contain the text 'System Notification File XXX', where XXX is the reference ID contained in row 1 field 1 of the corresponding System Notification File.

13.6.4   The 'From' line in an announcement email must contain the same email address as that listed in the sending Provider's field 4 entry in the List of Participants file.

13.6.5   The 'Reply-To' line in an announcement email must contain the same email address as that listed in the sending Provider's field 5 entry in the List of Participants file.

> *NOTE: This is to ensure that any unwilling recipient of announcement emails, for example because the emails have been inadvertently sent to the wrong recipient address due to error or bug in a Provider's implementation of an automated announcement process, have a return email address that is expected to be promptly checked.*

13.6.6   The date specified in the 'Date' line in an announcement email must not be after the notification date in row 1 field 2 of the corresponding System Notification File.

13.6.7   The body of the announcement email must contain a list of the email recipient's Systems that are affected by a change to the sender's System Notification File. Each recipient System identifier must be on a separate line in the email. The System identifiers should correspond with the identifiers specified in field 1 of the recipients System Notification File.

13.7   CSV file format requirements

13.7.1   Because there are many different implementations of the CSV file format, ambiguity or interpretation errors may arise in different implementations if different format assumptions are made by different participants. The purpose of this section is to exhaustively define the particular CSV format required for the System Notification Scheme.

13.7.2   The CSV file must be encoded using the UTF-8 alphabet.

13.7.3   The CSV file format uses commas (,) to separate fields.

NOTE: A comma has the hexadecimal 8 bit value of 0x2c.

13.7.4   Fields may optionally be encapsulated within double quote characters ("). The purpose of a double quoted field is to represent character strings that may optionally contain comma characters.

NOTES:

1. A double quote has the hexadecimal 8 bit value of 0x22.

2. Street addresses frequently contain comma characters.

13.7.5   When used, the double quote character must appear exactly twice in that field. The two occupied positions may only be the first and last characters of the field.

13.7.6   When double quotes are used to encapsulate a field, the effective length of the field should be taken to be the length of the sequence of characters between (but not including) the double quote characters.

13.7.7   Other than commas between paired double quotes, every instance of a comma should be interpreted as a field delimiter.

13.7.8   If additional fields appear beyond the last defined field of a record, they should be ignored.

13.7.9   The end of line (end of record) may be expressed in any of the following forms, each of which should be interpreted equivalently:

(a)   CR-LF (two bytes with hexadecimal values 0x0d 0x0a)

(b)   CR (a single byte with hexadecimal value 0x0d)

(c)   LF (a single byte with hexadecimal value 0x0a)

NOTES:

1. The default end of line representation is commonly different on Windows, OSX and Linux/Unix systems, but most software interprets all forms identically. It is straightforward to detect and

accommodate any form of end of line representation on any platform and to convert between these end of line formats.

2. The interpretation of an end of line differs slightly between different versions of a popular spreadsheet programme for Windows and OSX published by a popular office suite software vendor.

13.7.10   The last line in the CSV file should be terminated by one of the line record termination options defined in 13.7.9.

13.7.11   Interpretation of the System registration file should not require case sensitivity. Upper and lower-case letters carry the same meaning and should be interpreted as the same characters.

13.7.12   For all fields in the System registration file, leading and trailing spaces should be stripped. If present, leading and trailing space should be disregarded.

13.7.13   Fields that are not required to be used/filled may be left empty.

NOTES:

1. This means that there may be zero characters between commas in the System registration file, denoting an empty field.

2. A pair of adjacent double quotes ("") should be interpreted as if they represent an empty field.

13.7.14   The maximum field length for any field is 253 characters between commas; except when double quotes are used and the maximum number of characters between double quotes should be 253.

13.7.15   Other than the CR and LF characters, no other characters with a hexadecimal value below 0x20 should be appear in the CSV file.

13.7.16   No characters with a hexadecimal value greater than 0x7e (~) should appear in the CSV file.

NOTE: Any characters with a hexadecimal value below 0x20 which is not a CR or LF character or with a hexadecimal value greater than 0x7e should be silently ignored as if the character was not present in the CSV file.

14 EVIDENCE OF COMPLIANCE TO BE RETAINED BY SYSTEM PROVIDERS

This section describes evidence that should be prepared and retained by a System Provider and made available upon request to either the ACMA or to another Provider seeking to Deploy a System to a Shared Cable Bundle shared with the System about which the evidence is requested.

14.1 General for all Systems

14.1.1 In accordance with Sections 7.2.12.2 and 7.2.12.3 of Part 1, evidence of submission of valid application for a permit or connection, and evidence of any claimed associated delay.

14.1.2 In accordance with Sections 6.2.7, 11.1.6, 12.2.5.2 and 12.2.5.3 of Part 2, the technical details of the attenuation characteristics of a cable not appearing in Section 17 or Table 18 (refer to Appendix B) as relevant to the information sharing requirement, which have been relied upon for assessing Unacceptable Interference or Full Coverage.

14.1.3 In accordance with Sections 6.2.8 and 8.6.6.4 of Part 2 as relevant and only if this information has not already been made available in a record in the Provider's System Notification File,

   (a) the specific DPBO PSD Mask applied to a System, and

   (b) the tail attenuation between that System and the Main Distribution Frame or Joint at which the other System interconnects, and

   (c) all estimates of cable segment attenuations which have been used.

14.1.4 In accordance with Section 12.2.2 of Part 2:

   (a) calculations or evidence of processes demonstrating that applied DPBO PSD Mask designs protect Legacy Systems, and

   (b) evidence that UPBO has been applied in accordance with the requirements in section 12.2.2 of Part 2.

14.1.5 If a System is not covered by a valid record in a System Notification File published by the System's Provider, any information about that System described by any field of the System Notification File described in Table 13, as required to ensure harmonious coexistence in Shared Cable Bundles.

14.2 Deployment Class Systems

14.2.1 In accordance with Section A.8 of Part 3, substantiation that the parameters and sub-parameters described therein have been tested and found to comply with the requirements of Table 5 of Part 3, including substantiation of the test results themselves. Such

substantiation would usually come from the System vendor based on its own tests against the International Standards, although for the split Deployment Classes, the vendor or Provider would need to perform additional tests to confirm compliance with the DBPO PSD Masks.

14.3 Non-Deployment Class Systems

14.3.1 In accordance with sections 5.2.3 and 14.3.5 as relevant, a full technical report that demonstrates compliance of that Non-Deployment Class System with the relevant PSD Masks, and access to design, configuration, measurements, equipment, and facilities, if required by the committee of experts, for verification of the technical conclusions of the detailed technical report

14.3.2 In accordance with Section 5.2.3 if required, evidence:

(a) of the transmit PSD of its System in each direction under the full range of line conditions, and

(b) that the proposed Non-Deployment Class System does not emit Unacceptable Excess Power,

(c) that the Downstream and Upstream Coexistence Masks for Higher Priority Systems sharing a Shared Cable Bundle have not been exceeded,

(d) that all shaper designs and Deployed configurations do not cause Unacceptable Interference in any Shared Cable Bundle situations that may arise.

Providers of Non-Deployment Class Systems must also provide access to design, configuration, measurements, equipment, and facilities, if required, for verification of the technical conclusions of technical reports required here.

14.3.3 When alone in the Shared Cable Bundle, the Provider of a Non-Deployment Class System must retain details of the transmit PSD of its System in each direction under the full range of line conditions. That information may be retained either as a Limit PSD Mask for a standardised System or from measurements by a certified laboratory.

14.3.4 When required to share the customer Shared Cable Bundle with a Deployment Class System, a Non-Deployment Class System Provider is required to perform testing or analysis backed by testing to demonstrate that the proposed Non-Deployment Class System does not emit Unacceptable Excess Power either from the Non-Deployment Class CE or from the Non-Deployment Class DSLAM in any Deployed configuration of the Non-Deployment Class System.

14.3.5 Before commencing operation of a Non-Deployment Class System that will share a Shared Cable Bundle with either Legacy Systems or Deployment Class Systems, or if a Deployment Class System is subsequently Deployed to a Shared Cable Bundle

accessible from a Non-Deployment Class System in operation, Non-Deployment Class System Providers must obtain the relevant parameters of those other Systems and use those parameters to:

(a) Determine the relevant Downstream adjusted Coexistence Masks for the other Systems, as implemented; and

(b) Determine the highest Downstream transmit PSD from the Non-Deployment Class System DSLAM and refer it to the other System DSLAM location; then

(c) Demonstrate that the referred PSD Mask does not exceed the Downstream Coexistence Mask for that other System; and

(d) Determine the adjusted Upstream Coexistence Mask for that other System at each possible modem location; then

(e) Determine the highest Upstream PSD arriving at each possible modem location; then

(f) Demonstrate that the highest Upstream PSD arriving at each possible modem location does not exceed the Upstream Coexistence Mask for the other System at that location.

14.3.6 Non-Deployment Class System Providers must test or rigorously analyse their implementations to demonstrate that all shaper designs and Deployed configurations do not cause Unacceptable Interference in any Shared Cable Bundle situations that may arise.

14.3.7 Non-Deployment Class System Providers must test or rigorously analyse their implementations to demonstrate that Deployed configurations do not emit Unacceptable Excess Power.

14.4 Reporting Requirements

14.4.1 The results of testing or rigorous analysis must be formally recorded in technical reports which should, at a minimum, compare measurements of the TxPSD emitted by the DSLAM or CE with the required PSD Masks.

14.4.2 Required testing or rigorous analyses and the associated technical reports should be complete prior to the time that Systems are put into operation.

14.4.3 Upon request from a stakeholder or Provider of a Higher Priority System sharing a Shared Cable Bundle with a Non-Deployment Class System, the Non-Deployment Class System Provider must promptly make available a full technical report that demonstrates compliance of the Non-Deployment Class System, and must provide access to design, configuration, measurements, equipment, and facilities, if required, for verification of the technical conclusions of the detailed technical report.

> *NOTES:*
>
> *1. The testing, rigorous analysis and preparation of technical reports outlined in this section should be a one-off exercise. Generic testing and analysis of specific configurations and situations is sufficient to demonstrate compliance in the relevant configurations and situations*
>
> *2. Providing this information promptly is necessary to efficiently ascertain the likelihood of Interference disrupting the harmonious coexistence of the Non-Deployment Class System with a Deployment Class System.*

14.5 Unavoidable Extension of Implementation Phase

14.5.1 A System Provider should retain evidence of compliance with the Code for exceptional situations when implementing a System.

14.5.2 This includes situations that result in an unavoidable extension of time to deploy a System e.g. for the extension of up to three months permitted under section 7.2.12 in Part 1 of the Code.

> *NOTE: Clause 7.2.12.3 in Part 1 of the Code requires "An Initiator that meets the requirements for an extension must … retain relevant evidence of the delay".*

15 METHODS FOR CALCULATION OF DATA RATE AND COVERAGE FOR DEPLOYMENT CLASS SYSTEMS

15.1 Full Coverage Calculations

The purpose of this section is to provide the conditions and assumption for the calculation of the Full Coverage attenuation limits provided in Part 1. Those calculations, based on 8 like-disturbers within a 10 pair cable unit, yield the longest length of CAD55 (or Cat 5/6) cable that can support 25 Mbit/s or 50 Mbit/s Layer 2 Rate Downstream for each Deployment Class under the assumptions below. That length is multiplied by the CAD55 (or Cat 5/6) nominal attenuation per unit length at 3.75 MHz from Table 18 of Appendix B to obtain the Full Coverage attenuation limit for each of the 4 cases (25 Mbit/s CAD55, 50 Mbit/s CAD 55, 25 Mbit/s Cat5/6, 50 Mbit/s Cat 5/6). The models and assumptions here are also used for the calculation of Coexistence Masks.

> NOTE: The calculation of the Full Coverage attenuation limits for a System operating above 20 MHz (e.g. one using G.fast) is challenging because subtle changes in the operating environment can result in different outcomes . Instead, measurement of actual performance can inform an assessment of a TDD System for Full coverage.

15.2 The Australian cable environment

15.2.1 The predominant Australian cross-sectional cable topology is:

(a) groupings of ten twisted pairs within a 'sub-unit' (also known as a 'binder');

(b) further groupings of one, three, five, or ten sub-units within a unit; and

(c) one or more units comprising a cable 'sheath'.

15.2.2 For so-called drop cable and internal premises situations, the predominant cross-sectional cable topology is for single or two twisted pairs or quads within a sheath, and the dedication of such individual drop sheaths to a single end user premises.

15.2.3 For the purpose of consideration of Network cabling, it is commonplace for more than one cable sheath to share a cable duct (or conduit) or cable tray with other Network cabling cable sheaths.

15.2.4 It is commonplace for cabling sheaths to share a cable duct or cable tray with other drop cable sheaths for a proportion of the drop cable path.

15.3 Crosstalk in the Australian cable environment

15.3.1 For the frequencies of interest in this Code, other than for screened cable sheaths, crosstalk that affects service rates may

occur between different cable sheaths sharing a duct or cable tray.

15.3.2   For appropriately earthed screened cable sheaths only, crosstalk originating outside the screened cable sheath will not have an appreciable influence on the pairs within the screened cable sheath and vice versa. Screened cable sheaths may be treated as an independent Shared Cable Bundle from other cable sheaths.

15.3.3   For all kinds of cable, the strongest crosstalk interactions occur between the individual conductors within a sub-unit.

15.3.4   Crosstalk comprises the power sum of Far End Crosstalk (FEXT) and Near End Crosstalk (NEXT), based on the FSAN method described and used in Communications Alliance Code 559.

15.3.5   In practice, the magnitude of NEXT and FEXT is a statistical function influenced by variations in the geometry of the cables and the pairs within. For the purpose of simulating outcomes, it is generally accepted to model the 99th percentile, and this is often called the 'worst case'. The formulas presented in this section model the 99th percentile NEXT and FEXT levels.

15.3.6   Within the context of this Code, the algorithmic simulation approach described below must be used to determine the highest cable attenuation through which a Deployment Class System can achieve 25Mbit/s Layer 2 Rate Downstream (or 50 Mbit/s Layer 2 Rate Downstream) with 99th percentile confidence.

15.3.7   The 99th percentile confidence refers to the performance of a so called 'Victim' service in a Shared Cable Bundle context. The Victim is subject to crosstalk from other services including both other services hosted from the same System as hosting the Victim, as well as other services hosted by different Systems.
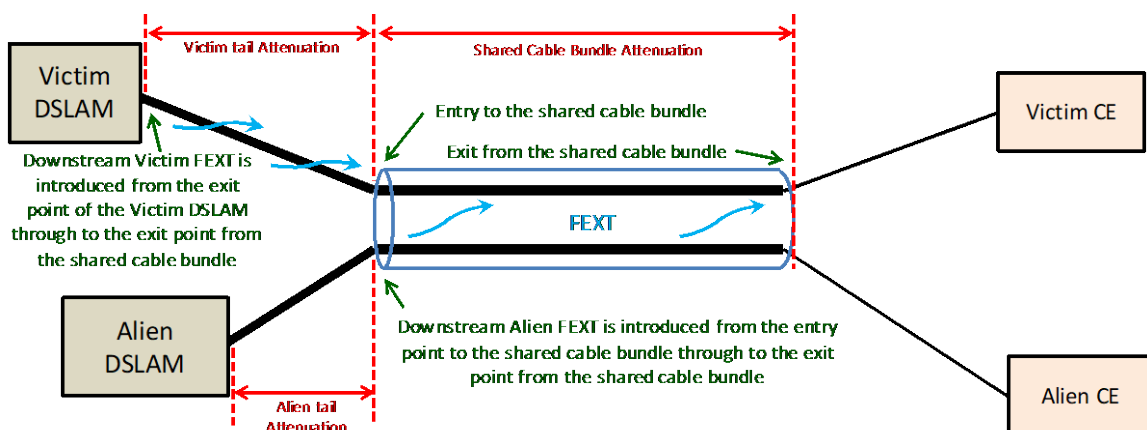
FIGURE 14

Victim Downstream FEXT impacting other services on the same System

15.3.8   FEXT is incurred at the far end of the cable path from the transmission sources from which the FEXT originates.

15.3.8.1 Downstream FEXT is incurred at the External Interface Port of the Victim's CE. Downstream FEXT comprises the far end crosstalk power sum from Downstream transmissions of other services originating both from the Victim and Alien DSLAMs.

15.3.8.2 Upstream FEXT is incurred at the External Interface Port of the Victim's DSLAM. Upstream FEXT comprises the far end crosstalk power sum from Upstream transmissions of other services originating both from the Victim and Alien CE.

15.3.9 The calculation for 99th percentile FEXT is outlined in Equation 12.

15.3.10 The FEXT Power Sum Ratio (F) is the ratio in dB of the far end received PSD of the n disturbing Systems to the total FEXT noise from those disturbers.

15.3.11 The calculation of F is expressed in terms of either Cat5/6 cable, or 0.4mm PIUT cable. When cables other than these are deployed, or when mixed cable types are deployed, an additional correction term must be considered in the final determination of FEXT.

EQUATION 12
99th percentile FEXT

Formulae	Notes
$F_{99th}(f, n, l) = 10 \log_{10}(f^2 l) + 6 \log_{10}\left(\frac{n}{4}\right) - \begin{cases} 55.0, & only\ Cat5\ or\ Cat6\ cables \\ 36.0, & other\ or\ mixed\ cables \end{cases}$ $Correction\ Term(l) = 10 \log_{10}\left(\frac{actual\ cable\ attenuation(1MHz)}{l \times reference\ cable\ attenuation(1MHz)}\right)$ $FEXT_{99th}(f, n, l) = TxPSD(f) + F_{99th}(f, n, l) + Correction\ Term(l) - H_{dB\ 99th}(f)$	f is expressed in MHz, n is number of FEXT contributors, l is the cable path length in km, FEXT and TxPSD are expressed in dBm/Hz The correction term is required when the cable type is other than purely Cat5/6 or 0.4mm PIUT

15.3.12 When simulating scenarios involving all services hosted by the same System, the 99th percentile far-end crosstalk (FEXT) level is the power sum crosstalk from 8 other co-located services of the same type in a 10-pair Tail Cable and Shared Cable Bundle binder.

As shown in Figure 13, FEXT occurs in both the Tail Cable and the Shared Cable Bundle, however each of these nine services are simulated with independent drop and internal end user premises wiring (i.e. no FEXT occurring in the drop and internal end user premises cable segments).

15.3.13 When simulating scenarios involving interference between an Alien System and the Victim, the 99th percentile FEXT level is the power sum crosstalk from 4 other co-located services hosted by the Victim System DSLAM, and 4 other services hosted by the Alien DSLAM.

The Victim and Alien DSLAMs may or may not be co-located, depending upon the scenario being considered.

FEXT from the four other Victim System services occurs in the Victim System Tail Cable and the Shared Cable Bundle. FEXT from the four other Alien Systems occurs only in the Shared Cable Bundle.
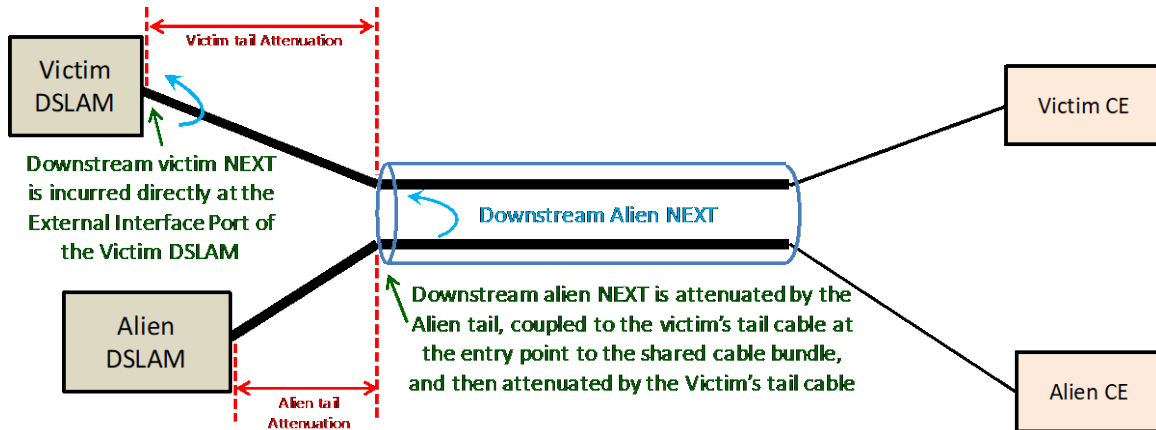
FIGURE 15

Downstream Alien NEXT impacting Victim Systems on another DSLAM

15.3.14 For Upstream Victim Systems, NEXT originates from both other Downstream Victim Systems hosted from the same DSLAM, and from Downstream Alien Systems hosted on other DSLAMs. As shown in Figure 14, NEXT sourced from the Victim DSLAM Systems is incurred at the External Interface Port of the Victim DSLAM, and the NEXT sourced from Alien Systems is incurred at the entry to the Shared Cable Bundle at its interface to the Alien Tail Cable.

15.3.15 For Downstream Victim Systems, NEXT originates both from other Upstream Victim Systems hosted from the same DSLAM, and from Upstream Alien Systems hosted on other DSLAMs. All NEXT from other Upstream services is incurred at the respective entry points to the Shared Cable Bundle at the interface to the respective drop cable.

15.3.16 Other than for NEXT caused by Downstream Victim Systems into an Upstream Victim, the PSD from which NEXT is calculated is firstly attenuated by the tail or drop cable connecting the source to the entry of the Shared Cable Bundle. The NEXT is incurred at the entry point to the Shared Cable Bundle. This NEXT is then attenuated by the tail or drop cable connecting the Shared Cable Bundle back to the Victim.

15.3.17 99th percentile NEXT is calculated in accordance with Equation 13. The NEXT Power Sum Attenuation (N) is the ratio in dB of one of n disturbing Systems to the total NEXT noise from those disturbers at the near end of the disturbed pair. The calculation of N is expressed in terms of either Cat5/6 cable, or 0.4mm PIUT cable.

EQUATION 13
99th percentile NEXT

Formulae	Notes
$$N_{99th}(f,n) = 15\log_{10}(f) + 6\log_{10}\left(\frac{n}{4}\right) - \begin{cases} 61.5, & \textit{only Cat5 or Cat6 cables} \\ 40.5, & \textit{other or mixed cables} \end{cases}$$ $$NEXT_{99th}(f,n) = TxPSD(f) + N_{99th}(f,n)$$	f is expressed in MHz in this calculation, n is number of NEXT contributors, NEXT and TxPSD are expressed in dBm/Hz

15.4 Targets for Deemed Sharing situations

The following rules apply to the determination of System ranges for Full Coverage and assessment of deemed coexistence scenarios.

15.4.1 In order to determine whether a second Deployment Class System is able to be listed as coexisting with a first Deployment Class System, it is only necessary that first Deployment Class System is not significantly degraded by the presence of the coexisting Deployment Class System in the Shared Cable Bundle.

15.4.2 In spectrum where the first Deployment Class System is non-Vectored, it is adequate to demonstrate for each direction of transmission that the transmitted PSD of the Coexisting System is equal to or below the PSD of the first Deployment Class System.

15.5 Vectoring

15.5.1 Vectoring is a technique for reducing the effects of FEXT. Because Vectoring requires full knowledge of the contents of every signal that is transmitted, it is not possible for a Victim System to achieve Vectoring gains upon crosstalk incurred from Aliens or any other source of external noise.

15.5.2 This raises the concept of 'cancellable noise' and 'uncancellable noise'. In its current form, Vectoring only applies to FEXT incurred from other services hosted by the Victim DSLAM – Vectoring does not apply to NEXT, and does not apply to any Alien source of crosstalk or noise.

15.5.3 Practically, Vectoring relies upon accurate measurement of the crosstalk coupling characteristics between every combination of pairs in a Shared Cable Bundle.

15.5.4 As crosstalk characteristics change over time, for example due to temperature changes or minute changes in the relative proximities of individual pairs with each other, these changes must be accurately tracked and accommodated by the Vectored Systems.

15.5.5   When a System cannot track changes in the crosstalk environment rapidly enough, Vectoring fails and services are likely to drop out. The behaviour of Vectoring Systems is therefore considerably more sensitive to rapid changes in the noise and cable environments than for any previous form of DSL technology.

15.5.6   A common cause of drop outs with Vectoring operation is the sudden appearance of Alien Systems in Spectrum That Overlaps hosted from another DSLAM, about which the Victim System has no prior warning.

15.5.7   The use of spectral splitting in this Code is intended to minimise this kind of drop out by minimising Spectrum That Overlaps.

15.5.8   Vectoring gains are calculated in accordance with Equation 14. The constants are defined in Table 15.

15.5.9   The Vectoring calculation is performed on 'cancellable FEXT' before that FEXT is summed with other 'uncancellable FEXT' and other forms of noise.

EQUATION 14
Gains from Vectoring

Formulae	Notes
$$V(f) = \begin{cases} CF(f) - Max\,Vect\,Gain, & CF(f) - Max\,Vect\,Gain \geq UN(f) + Min\,Vect\,Offset \\ UN(f) + Min\,Vect\,Offset, & CF(f) > UN(f) + Min\,Vect\,Offset \\ CF(f), & otherwise \end{cases}$$	VF = Vectored FEXT CF = cancellable FEXT UN = uncancellable noise

15.5.10   Vectoring can only reduce the cancellable component of FEXT to within MinVectOffset dB of the uncancellable noise floor.

15.5.11   Vectoring is also limited to cancelling a maximum of MaxVectGain dB.

15.5.12   The uncancellable noise floor is the noise addition of uncancellable noise sources including all forms of NEXT, Alien FEXT and QLN in accordance with Equation 16, which in turn relies on the calculations outlined in Equation 13, Equation 12, Equation 14 and Equation 15.

15.6   Summation of noise and crosstalk

15.6.1   The FSAN model is adopted by Communications Alliance for the summation of noise and crosstalk.

15.6.2 T1.E1.4/98-189 provides a detailed description and justification of the FSAN model. The model states that when summing multiple NEXT or FEXT disturbers (but not NEXT and FEXT together), the noise powers NEXT(f,n) or FEXT(f,n,l) (expressed in dBm/Hz) must be added to give the total noise power in accordance with Equation 15.

15.6.3 When combining contributions of noise and crosstalk, it is essential to ensure all noise estimates are of 99th percentiles.

EQUATION 15
Total NEXT and Total FEXT

Formulae	Notes
$Total\ NEXT_{99th}(f) = 6\log_{10}\left(\sum_{i=first\ NEXT\ source}^{last\ NEXT\ source} 10^{NEXTi_{99th}(f)/6}\right)$ $Total\ FEXT_{99th}(f) = 6\log_{10}\left(\sum_{i=first\ FEXT\ source}^{last\ FEXT\ source} 10^{FEXTi_{99th}(f)/6}\right)$	These equations sum the different components of NEXT, or the different components of FEXT, but should not be used for mixed forms of noise such as NEXT + FEXT + QLN. NEXT or FEXT magnitudes are expressed in dBm/Hz. 'Different components' refers to Alien and Victim

15.6.4 When adding NEXT, FEXT and QLN, the noise PSDs are added as outlined in Equation 16. As written, the equation requires upon all PSD levels being expressed in dBm/Hz.

EQUATION 16
Total Noise

Formulae	Notes
$Total\ Noise_{99th}(f) = 10\log_{10}\left(10^{Total\ NEXT_{99th}(f)/10} + 10^{Total\ FEXT_{99th}(f)/10} + 10^{QLN_{99th}(f)/10}\right)$	NEXT, FEXT, QLN and total noise magnitudes are expressed in dBm/Hz

15.7 Transceiver and environment assumptions

15.7.1 The VDSL2 transceiver is based on the assumptions in Table 14.

TABLE 14
VDSL2 transceiver assumptions

Parameter	Value
Tone Spacing	4312.5 Hz
Number of DMT symbols per second	4000
Minimum bits per tone (when loaded)	1

Parameter	Value
Maximum bits per tone (when loaded)	15
Gamma (the SNR margin required for 10^{-7} symbol error rate)	9.75 dB
Additional Noise Margin (NM)	6 dB
Coding Gain	4.2 dB
Maximum Transmitter Differential Power (The maximum power differential between the highest and lowest powered tones)	60 dB
Individual tone gains (Gi)	assumed to be parity (1.000)
Maximum Vectoring Gain Downstream	25 dB
Maximum Vectoring Gain Upstream	25 dB
Downstream Vectoring offset above the uncancellable noise floor	1.0 dB
Upstream Vectoring offset above the uncancellable noise floor	2.0 dB
Minimum Transmit PSD level in Coexistence Mask	-145 dBm/Hz
50th percentile Downstream QLN level (QLN at the External Interface Port of CE modem)	-137 dBm/Hz
50th percentile Upstream QLN level (QLN at the External Interface Port of DSLAM)	-137 dBm/Hz
99th percentile QLN	50th percentile QLN + 3 dB
Downstream Layer 2 overhead	12%
Upstream Layer 2 overhead	15%
Pilot tones (Tones notionally reserved for management and unavailable for carrying end user traffic)	capacity used for pilot tones is included in the aggregate simulation outcome
Number of 'guard tones' between Upstream and Downstream bands (tones not available to be loaded with bits)	6
Non Vectored bands	US0

NOTES:

1. Tones 6 to 32 in the US0 band are all available for loading with bits. The guard band between US0 and DS1 occupies tones 33 to 38. The guard band between all other adjacent Upstream and

> *Downstream bands occupies the three uppermost tones of the lower band, and three lowermost tones of the upper band.*
>
> *2. In actual Systems, a small number of tones are assigned as pilot tones and don't carry layer 2 payload. The specific tones used for pilot tones are not fixed in the ITU-T recommendation, and for the purpose of simulation for this Code, all usable tones are assumed to carry layer 2 payload.*
>
> *3. For each Vectored Deployment Class System, it is necessary to specify the tones or frequency ranges which are Vectored, to differentiate any bands or partial bands that are non Vectored.*

15.8 Method for calculation of bit rates

15.8.1 The calculation of bit rates is based upon application of the Shannon-Hartley channel capacity theorem for QAM modulated signals, and the water filling approach originally described by Chow, Cioffi and Bingham.

15.8.2 The approximation of the number of bits that can be loaded per tone per symbol is a function of the prevailing signal to noise ratio for that tone, the minimum SNR required to load one bit using QAM (gamma), the additional margin reserved by the implementation to accommodate instantaneous changes in SNR, and the coding gain achievable by the implementation through means of trellis and other techniques.

EQUATION 17
The bit loading function for QAM/DMT modulation

Formulae	Notes
$$SNR(t) = TxPSD(t) - H_{dB}(t) - Total\ Noise(t)$$ $$b(t) = min\left\{ \begin{array}{l} round\ nearest\left[\log_2\left(1 + 10^{[SNR(tone)-(Gamma+NM-Coding\ Gain)]/10}\right)\right] \\ Max\ Bits\ Per\ Tone \end{array}\right.$$ $$Bits\ Per\ Symbol = \sum_{t=lowest\ used\ tone}^{highest\ used\ tone} b(t)$$ $$Layer\ 2\ rate = Bits\ Per\ Symbol \times Symbols\ Per\ Second \times (1 - Layer\ 2\ Overhead)$$ Subject to the constraints $$\sum_{t=lowest\ used\ tone}^{highest\ used\ tone} Tone\ Spacing \times 10^{TxPSD(t)/10} \leq Max\ Aggregate\ Power$$ and $$max[TxPSD(t)] - min[TxPSD(t)] \leq Max\ Transmitter\ Differential$$	t is the integer tone number, based on frequency divided by tone spacing TxPSD and TotalNoise are expressed in dBm/Hz H$_{dB}$, SNR and MaxTransmitterDifferential are expressed in dB ToneSpacing is expressed in Hz MaxAggPower is expressed in mW The round nearest function rounds up or down to the nearest integer

15.8.3   The calculation of the bit rate must be subject to the constraint that the sum of powers of each tone must not exceed the aggregate maximum power for the transmitter.

> *NOTES:*
>
> *1. For B8-11 VDSL2 Systems, the maximum aggregate power is defined in the ITU-T recommendation as +14.5 dBm (which corresponds to approximately 28.1838 mW).*
>
> *2. In the Downstream direction for example, if all tones were to be hypothetically transmitted at the nominal ITU-T template, this aggregate maximum would be exceeded by a substantial margin.*

15.8.4   To comply with the ITU-T recommendation, all transmitters adopt a combination of:

(a)   choosing a maximum transmit power ceiling that is lower than the ITU-T template would otherwise permit, and

(b)   selectively discarding (i.e. not using) tones with the worst SNR so that the power that would have been wasted upon those poor tones is more usefully concentrated in tones with better SNR.

> *NOTE: Typically, the maximum transmit power ceiling for B8-11 VDSL2 service with an otherwise unimpaired line will be in the range -47 dBm/Hz to -57 dBm/Hz, varying according to loop attenuation, and nevertheless complying with the template constraints at higher frequencies.*

15.8.5   There can be a very large number of potential combinations of:

(a)   maximum transmit power ceiling values, and

(b)   used and disabled tones.

The bit loading outcomes for different combinations are not the same. In order to choose the optimal combination of transmit power ceiling and used tones, simulations should adopt an iterative water filling approach to discover the highest yielding combination. An iterative approach is described more fully in the pseudo code in section 15.10.

15.9   Confirmation of simulated results by laboratory testing

15.9.1   In order to correctly define the Deployment limits for new proposed Deployment Class Systems, and to ensure spectral compatibility between different coexisting Deployment Class Systems that could potentially be Deployed to the same Shared Cable Bundles, it is essential that new proposed Deployment Class Systems be thoroughly explored.

15.9.1.1 Software simulation is the most straightforward method to assess performance and impacts across the broadest

range of conditions, but its accuracy depends on the validity of a very wide range of assumptions.

15.9.1.2 Laboratory testing is the most reliable method to prove the validity of those assumptions about performance impacts and Deployment conditions, but it is not practical to undertake such an extensive programme of laboratory testing as required to prove the spectral compatibility between different Deployment Class System combinations.

15.9.1.3 It is therefore necessary to prove the viability of new Deployment Class System proposals through a combination of extensive simulation and selected laboratory verification.

15.9.2 Persons proposing new Deployment Class Systems must conduct laboratory testing to verify that the proposed new Deployment Class Systems are able to satisfy government policy objectives for the proposed Deployment conditions.

15.9.3 Persons proposing new Deployment Class Systems must conduct laboratory testing to verify that proposed new Deployment Class Systems coexist with proposed coexisting Deployment Class Systems such that the coexisting Deployment Class Systems satisfy government policy objectives for the proposed Deployment conditions.

15.9.4 Persons proposing new Deployment Class Systems must make the formal report of the simulation and laboratory testing results available to a committee of experts for peer review, and must work with the committee of experts to resolve questions and concerns.

15.9.5 Persons proposing new Deployment Class Systems must describe the simulation algorithms to a committee of experts in sufficient detail that the validity of the person's simulation results can be independently verified, and must work with the committee of experts to resolve questions and concerns.

15.10 Pseudo Code implementations of the formulas presented in this section

Pseudo code representing the formulas and algorithms described in this section are provided in Appendix A.

16   CABLE MODELS

16.1   Cat-5/6 and CAD55 Cable Attenuation Models

16.1.1   This section describes the Cat5/6 and CAD55 cable models defined in ITU-T G.9701.

16.1.2   For the purposes of this Code, these models are taken to represent the 50th percentile cable path attenuation.

16.1.3   The 99th percentile cable path attenuation is derived from the 50th percentile cable path attenuation by adding an additional offset amounting to 0.5 dB/km scaled according to $\sqrt{f}$, as outlined in Equation 7.

16.1.4   The CAT5/6 and CAD55 cable models are suitable for use up to frequencies including 212 MHz.

16.1.5   Refer to Table 15 for parameters for CAD55 and Cat-5 cables.

TABLE 15
Parameters for CAD55 and Cat-5 cables

Parametric cable constants	Constant values for CAD55 cable	Constant values for Cat5/6 cable
$Z_{0\infty}$	105.0694	98.0000
η_{VF}	0.6976	0.690464
R_{s0}	0.1871	0.1659
q_l	1.5315	2.1500
q_h	0.7415	0.85945
q_x	1	0.5
q_y	0	0.722636
q_c	1.0016	0
ϕ	-0.2356	973.846 x 10^{-6}
f_d	1	1
c_0	3 x 10^8	3 x 10^8
μ_0	4π x 10^{-7}	4π x 10^{-7}

16.1.6   For the purpose of describing cable traces when notifying Systems, the names of these cables described in Table 15 are 'CAD55' and 'CAT5'.

16.1.7   The parametric cable characteristics are derived by applying the cable constants into the formulae in Equation 18 through Equation 22 below.

EQUATION 18
Angular frequency formula

Formula	Notes
$\omega = 2\pi f$	f is expressed in Hz in this calculation

EQUATION 19
ITU-T G.9701 cable model constants

Formula	Notes
$$L_{S\infty} = \frac{Z_{0\infty}}{\eta_{VF} \cdot c_0}$$ $$C_{p0} = \frac{1}{\eta_{VF} \cdot c_0 \cdot Z_{0\infty}}$$ $$q_s = \frac{1}{q_h{}^2 \cdot q_l}$$ $$\omega_s = q_h{}^2 \left(\frac{4\pi \cdot R_{s0}}{\mu_0}\right)$$ $$\omega = 2\pi f_d$$	Constants, based on the cable specific parameters

EQUATION 20
ITU-T G.9701 cable model series impedance

Formulae	Notes
$$\delta = \left(q_s{}^2 + \frac{j\omega}{\omega_s} \cdot q_y\right) \Big/ \left(\frac{q_s{}^2}{q_x} + \frac{j\omega}{\omega_s} \cdot q_y\right)$$ $$Z = R_{S0}\left(1 - q_s \cdot q_x + \sqrt{q_s{}^2 \cdot q_x{}^2 + 2 \cdot \frac{j\omega}{\omega_s} \cdot \delta}\right) + j\omega L_{S\infty}$$	Calculation uses complex numbers

EQUATION 21
ITU-T G.9701 cable model shunt admittance

Formulae	Notes
$$Y = j\omega C_{p0} \cdot (1 - q_c) \cdot \left(1 + \frac{j\omega}{\omega_d}\right)^{\frac{-2\phi}{\pi}} + j\omega C_{p0} \cdot q_c$$	Calculation uses complex numbers

EQUATION 22
Resistance, Inductance, Capacitance and Conductance

Formulae	Notes
$R = Re(Z) \times 10^3$ $$L = Im\left(\frac{Z}{\omega}\right) \times 10^3$$ $$C = Im\left(\frac{Y}{\omega}\right) \times 10^3$$ $G = Re(Y) \times 10^3$	Units of R: Ω/km Units of L: H/km Units of C: F/km Units of G: S/km Calculation uses complex numbers

16.2 Other Cable Attenuation Models

16.2.1 This section describes models of other cables deployed in the Australian access network.

16.2.2 For the purposes of this Code, these models are taken to represent the 50th percentile cable path attenuation.

16.2.3 The 99th percentile cable path attenuation is derived from the 50th percentile cable path attenuation by adding an additional offset amounting to 0.5 dB/km scaled according to $\sqrt{f}$, as outlined in Equation 7.

16.2.4 These other cable attenuation models are suitable for use up to frequencies including 17.7 MHz.

16.2.5 Refer to Table 16 for parameters for other cable attenuation models. When used with Equation 22, these parameters yield resistance, capacitance, inductance and admittance as a function of frequency, for a nominal cable of length 1km. The actual cable length is taken into consideration in Equation 26.

TABLE 16
Parameters for 0.4mm cable attenuation models

R_{OC} a_c R_{OS} a_s L_O L_{inf} N_b f_m Parameters	0.4mm PIUT	0.4mm PEIUT	0.40mm PEILI	0.4mm CPFUT	0.4mm CPTIE ('thin' access network Tail Cable)
R_{OC}	271.793	265.84053	237.15079	268	286.17578
a_c	0.124169	0.17547	0.23475	0.089	0.1476962
R_{OS}	∞	2017.8889	2098.97476	∞	∞
a_s	∞	571.55228	1221.45198	∞	∞
L_O	6.43631E-04	7.00037E-04	7.08947E-04	8.3E-04	6.75369E-04
L_{inf}	4.28481E-04	5.822291E-04	6.233992E-04	6.0E-04	4.889519E-04
N_b	0.867987	1.7900038	1.72504689	0.7	0.92930728
f_m	1174080	743814.1	2406159.2	900000	806338.6
C_O	1.42340E-08	6.619372E-08	6.393535E-08	3.776776E-06	0
C_{inf}	3.46262E-08	1.190805E-08	1.725327E-08	4.3E-08	4.9E-08
N_{ce}	0.0389154	0.054773	0.0553516	0.7	0
G_O	6.1513439e-09	1.1000E-12	1.0891E-07	1.0E-11	4.3E-08
N_{ge}	0.97	1.23066	0.68004	1.0	0.7

16.2.6   For the purpose of describing cable traces when notifying Systems, the names of these cables described in Table 16 are 'PIUT40', 'PEIUT40', 'PEILI40', 'CPFUT40', and 'CPTIE'.

16.3   Generating the parametric cable characteristics for other cable types

16.3.1   The parametric cable characteristics are derived by applying the cable constants into Equation 23.

EQUATION 23
The BT#1 parametric cable model

Formula	Notes
$$R(f) = \left(\frac{1}{\sqrt[4]{R_{0c}{}^4 + a_c f^2}} + \frac{1}{\sqrt[4]{R_{0s}{}^4 + a_s f^2}} \right)^{-1}$$ $$L(f) = \left(L_0 + L_\infty \left({}^f/_{f_m} \right)^{N_b} \right) \Big/ \left(1 + \left({}^f/_{f_m} \right)^{N_b} \right)$$ $$C(f) = C_\infty + \frac{C_0}{f^{N_{ce}}}$$ $$G(f) = G_0 \times f^{N_{ge}}$$	f is expressed in Hz in this calculation Units of R: Ω/km Units of L: H/km Units of C: F/km Units of G: S/km

16.4 Deriving attenuation from parametric cable characteristics

16.4.1 An ABCD transmission line matrix is derived using Equation 24 through Equation 26.

16.4.2 Cable networks comprising jointed Shared Cable Bundles may be simulated by multiplying the sequence of transmission line matrices representing the sequence of Shared Cable Bundles.

EQUATION 24
Deriving the propagation constant of a cable segment

Formula	Notes
$\gamma = \sqrt{(R + j\omega L) \times (G + j\omega C)}$	Calculation uses complex numbers

EQUATION 25
Deriving the characteristic impedance of a cable segment

Formula	Notes
$Z_0 = \sqrt{\dfrac{(R + j\omega L)}{(G + j\omega C)}}$	Calculation uses complex numbers

EQUATION 26
Deriving the ABCD matrix representation of a cable segment

Formula	Notes
$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \cosh(\gamma l) & Z_0 \cdot \sinh(\gamma l) \\ {}^{\sinh(\gamma l)}/_{Z_0} & \cosh(\gamma l) \end{bmatrix}$	Calculation uses complex numbers 'l' is the length of cable section (km)

16.4.3   Cable attenuation as a function of frequency is derived using Equation 27 from the 'ABCD' matrix representing the end to end cable path.

16.4.4   Attenuation is expressed in units of dB/km.

EQUATION 27
Calculated cable System attenuation as a function of frequency

Formula	Notes
$$H(f) = -20 \log_{10} \left| \frac{Z_l + Z_s}{AZ_l + B + CZ_lZ_s + DZ_s} \right|$$	Calculation uses complex numbers. The cable is terminated at each end into Z_s and Z_l which are each assumed to be 100Ω purely resistive loads. The values of A, B, C and D are taken from the corresponding ABCD matrix representation of the end to end cable path. The cable attenuation H(f) is expressed in dB

17 REFERENCES

Publication	Title
Industry Codes	
C559:2012	Unconditioned Local Loop Service (ULLS) Network Deployment https://commsalliance.com.au/Documents/all/codes/c559
Industry Guidelines	
G649:2017	Cabling existing telecommunications services in the customer's premises for the NBN https://commsalliance.com.au/Documents/all/guidelines/g649
International Telecommunications Union Recommendations	
G.993.2 (12/2019)	Very high speed digital subscriber line transceivers 2 (VDSL2) https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=13747&lang=en
G.993.5 (04/2019)	Self-FEXT cancellation (Vectoring) for use with VDSL2 transceivers https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=13748&lang=en
Legislation	

Telecommunications Act 1997

https://www.legislation.gov.au/C2004A05145/latest/versions

Other

A normal limit theorem for power sums of independent random variables,

N. A. Marlowe

Vol. 46, pp. 2081-2089, Bell Syst. Tech. Journal, 1967

Some properties of power sums of truncated normal random variables.

I. Nasell

Vol. 46, pp. 2091-2110, Bell Syst. Tech. Journal, 1967

APPENDIX

A   PSEUDO CODE IMPLEMENTATIONS OF THE FORMULAS PRESENTED IN SECTION 14

```
// This section outlines constants for the System being modelled, reflecting
// constants described in section 15.6.1
#define MAX_AGG_POW_DBM        (+14.5) // dBm, G993.2 table 6.1
#define MAX_BITS_PER_TONE      (15)    // bits, G993.2 section 1
#define TONE_BANDWIDTH         (4312.5)// Hz, G993.2 table 6.1
#define NUM_TONES              (4096)  // tones, VDSL2 17a: tones numbered 0 to 4095
#define NUM_POTENTIAL_TONES_DS (2895)  // tones, VDSL2 17a (sum of DS1, DS2, DS3)
#define NUM_POTENTIAL_TONES_US (1161)  // tones, VDSL2 17a (sum of US0, US1, US2)
#define NUM_SYMBOLS_PER_SECOND (4000)  // DMT symbols per second, VDSL2 17a
#define TONE_1MHZ              (232)   // Tone corresponding to a frequency of 1MHz
#define ZERO_POWER             (-200)  // dBm/Hz - a power level that's effectively 0


// CommsAlliance assumptions
#define GAMMA                  (9.75)  // dB, SNR margin for 10⁻⁷ bit error rate
#define NOISE_MARGIN           (6.0)   // dB, additional SNR margin for stability
#define CODING_GAIN            (4.2)   // dB, SNR benefit from trellis coding
#define MAX_DIFFERENTIAL_POWER (60)    // dB, max between highest and lowest tone pwr
#define MAX_VECTORING_GAIN_DS  (25)    // dB, max DS FEXT cancellable by vectoring
#define MAX_VECTORING_GAIN_US  (25)    // dB, max US FEXT cancellable by vectoring
#define VECT_OFFSET_DS         (1.0)   // dB, gap above uncancellable noise floor DS
#define VECT_OFFSET_US         (2.0)   // dB, gap above uncancellable noise floor US
#define QLN_LEVEL_DS           (-134)  // dBm/Hz, flat across the spectrum (99ᵗʰ %)
#define QLN_LEVEL_US           (-134)  // dBm/Hz, flat across the spectrum (99ᵗʰ %)


#define HLOG_PIUT40_1MHZ       (25.4)  // dB/km, attenuation of 0.4mm PIUT (at 1MHz)
#define LAYER_2_OVERHEAD_DS    (0.12)  // difference between L2 and bit_loader rate
#define LAYER_2_OVERHEAD_US    (0.15)  // difference between L2 and bit_loader rate

// Arrays referenced in this pseudo-code are not all explicitly defined in the pseudo
// code, but have the following form (shown with index contained in '[]')
double Hlog     [NUM_TONES] ;          // Hlog is the loop attenuation, in dB
double Template [NUM_TONES] ;          // Template TxPSD, in dBm/Hz
// (and so on...)

int   Lines_In_Shared_Bundle ;         // Num services in shared cable bundle
```

```
// Adds a similar noise source to an existing noise array according to EQUATION 15
// The values of the variables in the formula below are expressed in dB
add_similar_noise_types (double sum[], double noise_to_be_added[])
{
 int i ;

 for (i=0 ; i < NUM_TONES ; i++)
  sum[i] = 6 * log10((pow(10, sum[i]/6) + pow(10, noise_to_be_added[i]/6)) ;
}
```

```
// Adds a dissimilar noise source to an existing noise array per EQUATION 16
// The values of the variables in the formula below are expressed in dB
add_dissimilar_noise_types (double sum[], double noise_to_be_added[])
{
 int i ;

 for (i=0 ; i < NUM_TONES ; i++)
  sum[i] = 10 * log10((pow(10, sum[i]/10) + pow(10, noise_to_be_added[i]/10)) ;
}
```

```
// vector determines the amount of noise that can be cancelled per EQUATION 14
// On entry, the FEXT array contains the cancellable noise, and the
// uncancellable_noise array contains the QLN + NEXT + alien FEXT
// The values of the variables in the formulas below are expressed in dB
vector (double FEXT[], double uncancellable_noise[], double max_vect_gain,
    double min_vect_offset)
{
 int i ;

 for (i=0 ; i < NUM_TONES ; i++)
 {
  // The maximum vectoring gain only applies when the cancelled FEXT level exceeds
  // the uncancellable noise plus the minimum vectoring offset level. Vectoring
  // cannot cancel noise below that level
  if ((FEXT[i] - max_vect_gain) >= (uncancellable_noise[i] + min_vect_offset))
   FEXT[i] -= max_vect_gain ;

  // If FEXT level is higher than the gap, cancel FEXT down to min vectoring offset
  else if (FEXT[i] > (uncancellable_noise[i] + min_vect_offset))
   FEXT[i] = uncancellable_noise[i] + min_vect_offset ;

  // Otherwise, the FEXT is below the gap offset, so leave unchanged.
  // Vectoring can bring no benefit for crosstalk levels below the gap offset
 }
}
```

```
// FEXT function represents the CA FEXT algorithm per EQUATION 12
// It assumes 10-pair cable binders as commonly deployed in the Australian network.
// The values of the variables in the formulas below are expressed in dB
//
// The pseudo code is written from the perspective of a 0.4mm PIUT reference
// cable. In the special case of simulating cat5 or equivalent cables, there is no
// requirement to use the atten_correction_term, and the constant in the FEXT_PSR
// expression should be 55.0 rather than 36.0.

CommsAlliance_FEXT (double FEXT[], double TxPSD[], double Hlog[], int n_xtalkers)
{
 int  i ;
 double freq_MHz, FEXT_PSR_dB, xtalkers_term, coupling_term, atten_correction_term ;

 // Other than for cat 5 or similar cables, crosstalk for cables other than 0.4mm PIUT
 // needs to be corrected for the attenuation difference relative to the 0.4mm PIUT
 // cable type. The normalisation frequency for CA crosstalk measurements is 1 MHz.
 // The length of the cable represented by the Hlog array (i.e. 'length (Hlog[])')
 // is expressed in km.

 atten_correction_term = 10.0 * log10(Hlog[TONE_1MHz] /
                    (HLOG_PIUT40[TONE_1MHZ] * length(Hlog[])) ;

 fill_array (FEXT[], ZERO_POWER) ;

 for (i=0 ; i < NUM_TONES ; i++)
 {
  // f is in MHz and length in km.
  freq_MHz = (i * TONE_BANDWIDTH) / 1000000 ;

  if ((n_xtalkers > 0) && (TxPSD[i] > ZERO_POWER))
  {
   xtalkers_term = 6.0 * log10(n_xtalkers / 4.0) ;
   coupling_term = 10.0 * log10(freq_MHz * freq_MHz * length(Hlog[])) ;

   FEXT_PSR_dB = 36.0 - xtalkers_term - coupling_term - atten_correction_term ;
   FEXT[i] = TxPSD[i] - FEXT_PSR_dB - Hlog[i] ;
  }
 }
}
```

```c
// NEXT function represents the CA FEXT algorithm per EQUATION 13
// It assumes 10-pair cable binders as commonly deployed in the Australian network.
// The values of the variables in the formulas below are expressed in dB
//
// The pseudo code is written from the perspective of a 0.4mm PIUT reference
// cable. In the special case of simulating cat5 or equivalent cables, the constant
// in the NEXT_PSA_dB expression should be 61.5 rather than 40.5.

CommsAlliance_NEXT (double NEXT[], double NEXT_Template[], int n_xtalkers)
{
 int  i ;
 double freq_MHz, NEXT_PSA_dB, xtalkers_term, frequency_term ;

 fill_array (NEXT[], ZERO_POWER) ;

 for (i=0 ; i < NUM_TONES ; i++)
 {
  // f is in MHz
  freq_MHz = (i * TONE_BANDWIDTH) / 1000000 ;

  if ((n_xtalkers > 0) && (NEXT_Template[i] > ZERO_POWER))
  {
   xtalkers_term = 6.0 * log10(n_xtalkers / 4.0) ;
   frequency_term = 15.0 * log10(freq_MHz) ;

   NEXT_PSA_dB = 40.5 - xtalkers_term - frequency_term ;
   NEXT[i] = NEXT_Template[i] - NEXT_PSA_dB ;
  }
 }
}
```

```c
// The bit_load function represents the algorithm described by EQUATION 17
// It determines the number of bits that can be conveyed in each DMT symbol, for a
// particular cable attenuation, noise background, transmit template, and the ceiling
// level for transmit power. The maximum allowable transmit power (integrated over
// all tones) is limited by G993.2 to a level well beneath the power required to
// 'fill' the template PSD Mask. Power is consumed sequentially starting from the
// lowest frequency tone until the G993.2 power budget is consumed. Higher frequency
// tones are then disabled. By reducing the transmit power ceiling, more power is
// available for higher frequency tones.
//
// The graph of the bit_load function vs txpsd_ceiling is a concave down curve.
// The highest point on this curve is the desired 'optimum' (maximum possible rate).
int bit_load (double TxPSD[], double Hlog[], double Noise[], int tones,
        double txpsd_ceiling)
{
 int   i, b, usable ;
 double gap, power_sum, max_agg_pow_mW, SNR[NUM_TONES] ;

 // Determine the Signal To Noise Ratio for the supplied TxPSD, Hlog and Noise
 // The formula below uses power and attenuation levels in dB (as opposed to linear)
 calculate (SNR[] = TxPSD[] - Hlog[] - Noise[]) ;

 // Sort the SNR array into descending order, co-sorting with txpsd array elements
 // Note: 'Co-sorting' means ensuring the TxPSD elements remain aligned with the
 // corresponding SNR elements, as the order of the SNR elements is sorted
 sort_descending (SNR[], TxPSD[]) ;

 // This section determines number of usable tones with available MAX_AGG_POW power
 power_sum = 0 ;
 max_agg_pow_mW = pow(10, MAX_AGG_POW_DBM / 10) ;

 for (usable=0 ; (usable < tones) && (power_sum < max_agg_pow_mW) ; usable++)
 {
  tone_power = min(txpsd_ceiling, TxPSD[usable]) ;

  // Tone powers that would be below transmitter's dynamic range are ignored
  if (tone_power < (txpsd_ceiling - MAX_DIFFERENTIAL_POWER))
   break ;

  power_sum += pow(10, tone_power / 10) * TONE_BANDWIDTH ;
 }

 // At this point, the power_sum has just exceeded the maximum, but because 'usable'
 // counted from zero, the value it contains represents the actual usable # tones.
 //
 // This section determines the bit-loading sum for this QAM symbol based on the
 // usable number of tones determined above
 //
 // The formulas below use power levels in dB (as opposed to linear)

 // The gap is the minimum SNR required to load one QAM bit at the desired margin
 gap = GAMMA + NOISE_MARGIN - CODING_GAIN ;

 for (bits_in_symbol=0, i=0 ; (i < usable) && (SNR[i] > gap) ; i++)
 {
 b = round_to_nearest_int (log2(1 + pow(10, (SNR[i] - gap) / 10))) ;

  if (b > MAX_BITS_PER_TONE)
   b = MAX_BITS_PER_TONE ;

  bits_in_symbol += b ;
 }

 return bits_in_symbol ;
}
```

```c
// The optimal_rate function implements the water filling algorithm required by
// by EQUATION 17. It finds the settings that maximise bit loading per DMT symbol.
//
// Because tone power changes as the combinations of usable tones is iterated, the
// noise environment (ie FEXT and NEXT) must be recalculated for each combination.
//
// Calculation of the noise environment depends on the cable topology and whether
// vectoring is being used or not.
//
// Alien FEXT only occurs in the shared cable segment.
// Self FEXT occurs in the shared cable segment and self tail segment
// Downstream alien NEXT is attenuated by the Alien Tail and again by the Self Tie
// Upstream NEXT is attenuated by the neighbouring lead-in and your own lead-in
int optimal_rate (int potential_tones, Boolean vectoring, Boolean doing_downstream)
{
 int   bits_in_symbol, max_bits_in_symbol, tones ;
 double max_agg_pow_mW, txpsd_ceiling ;

 // Power aggregation must be calculated in mW (ie in a linear scale)
 max_agg_pow_mW = pow(10, MAX_AGG_POW_DBM / 10.0) ;
 max_bits_in_symbol = bits_in_symbol = 0 ;

 // The bit loader is only interested in tones usable in the transmission direction
 if (doing_downstream)
 {
  set_masked_tones_to_zero_power (Self_Template_psd_DS[]) ;
  set_masked_tones_to_zero_power (Alien_Template_psd_DS[]) ;
  set_unmasked_tones_to_zero_power (Self_NEXT_psd_US[]) ;
  set_unmasked_tones_to_zero_power (Alien_NEXT_psd_US[]) ;
 }
 else // doing upstream
 {
  set_masked_tones_to_zero_power (Self_Template_psd_US[]) ;
  set_masked_tones_to_zero_power (Alien_Template_psd_US[]) ;
  set_unmasked_tones_to_zero_power (Self_NEXT_psd_DS[]) ;
  set_unmasked_tones_to_zero_power (Alien_NEXT_psd_DS[]) ;
 }

 for (tones=potential_tones ; tones > 0 ; tones--)
 {
  // The lower the txpsd ceiling, the more tones which can be used before exceeding
  // the maximum aggregate power. Each iteration in this loop increases the ceiling
  // but has the effect of reducing the maximum number of used tones
  txpsd_ceiling = 10 * log10(max_agg_pow_mW / tones / TONE_BANDWIDTH) ;

  // Apply the ceiling to the template PSD. This has the effect of chopping the top
  // off the template, but transferring the saved power into higher frequency tones
  for (i=0 ; i < NUM_TONES ; i++)
   Self_Txpsd[i] = min(txpsd_ceiling, Template[i]) ;

  // Self xtalk will occur in the DSLAM tail cable and shared cable bundle
  if (doing_downstream)
  {
   calculate (Self_Next_psd[] = Self_NEXT_psd_US[] -(2*LeadIn_And_Internal[])) ;
   set    (Self_Temp_psd[] = Self_Txpsd[]) ;
   calculate (Alien_Next_psd[] = Alien_NEXT_psd_US[] -(2*LeadIn_And_Internal[])) ;
   calculate (Alien_Temp_psd[] = Alien_FEXT_psd_DS[] - Alien_Tie[]) ;
  }
  else // Doing upstream
  {
   set    (Self_Next_psd[] = Self_NEXT_psd_DS[]) ;
   calculate (Self_Temp_psd[] = Self_Txpsd[]    - LeadIn_And_Internal[]) ;
   calculate (Alien_Next_psd[] = Alien_NEXT_psd_DS[] - Alien_Tie[]) ;
   calculate (Alien_Temp_psd[] = Alien_FEXT_psd_US[] - LeadIn_And_Internal[]) ;
  }
```

```
   // Determine non-vectored NEXT and FEXT based on txpsd level at entry to shared
   // cable bundle. Num Xtalkers is one less than num lines in shared cable bundle
   CommsAlliance_NEXT (Self_NEXT[], Self_Next_psd[], Lines_In_Shared_Bundle - 1) ;
   CommsAlliance_FEXT (Self_FEXT[], Self_Temp_psd[],
            Self_Tie[] + Shared_Cable_Bundle[],
            Lines_In_Shared_Bundle - 1) ;
   CommsAlliance_NEXT (Alien_NEXT[], Alien_Next_psd[], Lines_In_Shared_Bundle - 1) ;
   CommsAlliance_FEXT (Alien_FEXT[], Alien_Temp_psd[], Shared_Cable_Bundle[],
            Lines_In_Shared_Bundle - 1) ;

   if (doing_downstream)
   {
    // Subtract lead-in cable attenuation if doing downstream, because the FEXT
    // will be attenuated along with the actual signal
    subtract (Self_FEXT[] -= LeadIn_And_Internal[]) ;
    subtract (Alien_FEXT[] -= LeadIn_And_Internal[]) ;
    subtract (Self_NEXT[] -= LeadIn_And_Internal[]) ;
    subtract (Alien_NEXT[] -= LeadIn_And_Internal[]) ;
   }
   else // doing upstream
   {
    subtract (Alien_FEXT[] -= Self_Tie[]) ;
    subtract (Alien_NEXT[] -= Self_Tie[]) ;
   }

   // What happens next depends on whether we're vectoring or not. For vectoring,
   // we need to vector above the 'uncancellable noise floor' - because we cannot
   // vector to a lower SNR than permissible by the 'uncancellable noise floor'
   if (vectoring)
   {
    // The 'uncancellable noise floor' is QLN + alien/self NEXT + alien FEXT
    set (Noise[] = QLN[]) ;
    set (NEXT_Sum[] = Alien_NEXT[]) ;
    add_similar_noise_types (NEXT_Sum[], Self_NEXT[]) ;
    add_dissimilar_noise_types (Noise[], NEXT_Sum[]) ;
    add_dissimilar_noise_types (Noise[], Alien_FEXT[]) ;

    if (doing_downstream)
     vector (Self_FEXT[], Noise[], MAX_VECTORING_GAIN_DS, VECT_OFFSET_DS) ;
    else
     vector (Self_FEXT[], Noise[], MAX_VECTORING_GAIN_US, VECT_OFFSET_US) ;
   }

   // The 'Self_FEXT' array now contains vectored crosstalk (if vectoring)
   // Calculate the final noise environment upon which we will bitload
   set (Noise[] = QLN[]) ;
   set (NEXT_Sum[] = Alien_NEXT[]) ;
   add_similar_noise_types (NEXT_Sum[], Self_NEXT[]) ;
   add_dissimilar_noise_types (Noise[], NEXT_Sum[]) ;
   set (FEXT_Sum[] = Alien_FEXT[]) ;
   add_similar_noise_types (FEXT_Sum[], Self_FEXT[]) ;
   add_dissimilar_noise_types (Noise[], FEXT_Sum[]) ;

   // Finally, determine the optimal bit loading for this txpsd level
   bits_in_symbol = bit_load (Self_Txpsd[],
            Self_Tie[] + Shared_Cable_Bundle[] + LeadIn_And_Internal[],
            Noise[], tones, txpsd_ceiling) ;

   if (bits_in_symbol > max_bits_in_symbol)
    max_bits_in_symbol = bits_in_symbol ;
  }

  return max_bits_in_symbol * NUM_SYMBOLS_PER_SECOND ;
}
```

```
// create_UPBO_mask function generates an upstream mask based on Hlog and a/b
// parameters. NOTE: The algorithm below is intended to apply only to VDSL2 systems
// as per G993.2 section 7.2.1.3
apply_UPBO_mask (double Template[], double Hlog[], double a1, b1, a2, b2, a3, b3)
{
 int  i ;
 double low_tone ;
 double root_freq_MHz ;
 double KL0 ;
 double estimated_KL0 ;
 double t ;
 double UPBO_Mask [NUM_TONES] ;

 // kl0 = min (loss(f) / sqrt(f)) for f in MHz and f >= 1 MHz
 KL0 = 1e10 ;

 // Keep only usable tones in the upstream direction, all other tones disabled
 set (UPBO_Mask[] = Template[]) ;
 set_masked_tones_to_zero_power (UPBO_Mask[]) ;
 low_tone = round_to_nearest_int (1000000 / TONE_BANDWIDTH) ;

 for (i=low_tone ; i <= NUM_TONES ; i++)
 {
  // If the received signal power is below the threshold - ignore this tone
  if ((UPBO_Mask[i] - Hlog[i]) < -130)
   continue ;

  root_freq_MHz = sqrt(i * TONE_BANDWIDTH / 1000000) ;
  estimated_KL0 = Hlog[i] / root_freq_MHz ;

  if (estimated_KL0 < KL0)
   KL0 = estimated_KL0 ;
 }

 // Floor value of kl0 is 1.8, as per G993.2 section 7.2.1.3.2.2
 if (KL0 < 1.8)
  KL0 = 1.8 ;

 // Finally prepare the UPBO mask
 for (i=0 ; i < NUM_TONES ; i++)
 {
  // The UPBO mask definition is outlined in G993.2 s7.2.1.3.2.2
  root_freq_MHz = sqrt(i * TONE_BANDWIDTH / 1000000) ;

  if (i in US0)
   continue ;

  else if (i in US1)
   t = -(a1 + (b1 * root_freq_MHz)) + (KL0 * root_freq_MHz) ;

  else if (i in US2)
   t = -(a2 + (b2 * root_freq_MHz)) + (KL0 * root_freq_MHz) ;

  else if (i in US3)
   t = -(a3 + (b3 * root_freq_MHz)) + (KL0 * root_freq_MHz) ;

  else
   continue ;

  if (t < UPBO_Mask[i])
   UPBO_Mask[i] = t ;
 }
 // Mask over the template with the calculated UPBO mask
 set (Template[] = UPBO_Mask[]) ;
}
```

```c
// Preparation of the 99th percentile attenuation requires adding 0.5dB/km at 1MHz,
// and scaling this offset according to root(f), as defined in EQUATION 7
prepare_attenuation (double Atten_99th_percentile[], double cable_model[])
{
 int i ;
 double root_freq_MHz, cable_length ;

 cable_length = length(cable_model[]) ;

 for (i=0 ; i < NUM_TONES ; i++)
 {
  root_freq_MHz = sqrt(i * TONE_BANDWIDTH / 1000000) ;
  Atten_99th_percentile[i] = cable_model[i] + (0.5 * root_freq_MHz * cable_length);
 }
}
```

```
// Pseudo code that ties the functions above together into a simulation scenario
int simulate (Boolean doing_downstream, Boolean doing_vectoring)
{
 int bit_rate, Layer_2_Rate ;

 // Prepare the TxPSD template mask and determine the number of usable tones
 prepare_txpsd_template (Self_NEXT_psd[]) ;  // NEXT template (from own system)
 prepare_txpsd_template (Alien_NEXT_psd[]) ;  // NEXT template (from alien system)
 prepare_txpsd_template (Self_Template_psd[]) ; // Template PSD (for own system)
 prepare_txpsd_template (Alien_Template_psd[]) ; // Template PSD (for alien system)

 // Prepare attenuations of each cable segment
 prepare_attenuation (Self_Tie[]) ;
 prepare_attenuation (Alien_Tie[]) ;
 prepare_attenuation (Shared_Cable_Bundle[]) ;
 prepare_attenuation (LeadIn_And_Internal[]) ;
 // Note: lead-in and internal cable are assumed identical for self and alien

 if (doing_downstream)
 {
  prepare_QLN_array (QLN[], QLN_LEVEL_DS) ;
  bit_rate = optimal_rate (NUM_POTENTIAL_TONES_DS, doing_vectoring, True) ;
  Layer_2_rate = bit_rate * (1 - LAYER_2_OVERHEAD_DS) ;
 }
 else // doing upstream
 {
  // create array of QLN matching the simulation requirements for 99th percentile
  prepare_QLN_array (QLN[], QLN_LEVEL_US) ;

  // For upstream VDSL2 simulations, the template needs to be limited by UPBO
  // Both the alien and the victim systems apply UPBO in upstream direction
  apply_UPBO_mask (Self_Template_psd[],
          Self_Tie[] + Shared_Cable_Bundle[] + LeadIn_And_Internal[],
          a1, b1, a2, b2, a3, b3) ;

  apply_UPBO_mask (Alien_Template_psd[],
          Alien_Tie[] + Shared_Cable_Bundle[] + LeadIn_And_Internal[],
          a1, b1, a2, b2, a3, b3) ;

  bit_rate = optimal_rate (NUM_POTENTIAL_TONES_US, doing_vectoring, False) ;

  // The following adjustment to convert the raw bitloader output into a layer 2
  // rate is an approximation. The precise ratio is a complex function of several
  // variables, one of which is the packet size. The simple approximation below
  // has been found to be reasonably representative for the purpose of modelling
  // for this Code. The Layer 2 rate is relevant because the Australian government
  // policy is drafted with respect to Layer 2 rates experienced by end users.
  Layer_2_rate = bit_rate * (1 - LAYER_2_OVERHEAD_US) ;
 }

 return Layer_2_rate ;
}
```

APPENDIX

B   CABLE LOSSES

B1   Background

Telecommunications companies in Australia have been deploying twisted pair cables since the early in the 20th Century. Today there is a large deployment of this cable which may be usable for modern and emerging twisted pair communications protocols. This appendix provides attenuation and crosstalk models for common cables in the Australian context.

B2   PER KILOMETRE CABLE LOSSES AT 300 KHZ AND 3.75 MHZ

Table 17 has per kilometre cable losses at 300 kHz and 3.75 MHz for several cables used in Australia.

TABLE 17
50th percentile Cable loss in dB/km at 300 kHz and 3.75 MHz for common cable types and gauges

Cable Type	Attenuation at 300 kHz (dB/km)	Attenuation at 3.75 MHz (dB/km)	Cable Type	Attenuation at 300 kHz (dB/km)	Attenuation at 3.75 MHz (dB/km)
0.32mm PIUT	16.5	59.5	0.81mm APIUT	8.2	34.4
0.40mm PIUT	13.8	53.5	0.90mm PIUT	6.4	27.9
0.40mm PEIUT	11.5	38.6	0.90mm PIQL	7.6	33.9
0.40mm CPIUT	12.8	44.7	0.90mm PIQC	5.7	24.8
0.40mm CPFUT	10.8	37.6	0.90mm PEIUT	4.7	16.8
0.51mm PIQL	11.9	51.5	0.90mm CPIUT	5.7	21.1
0.51mm PEIQL	9.4	33.0	0.90mm CPFUT	6.0	21.1
0.51mm PEIUQ	9.4	33.0	0.90mm PIQJ	7.1	32.3
0.52mm APIUT	12.9	51.5	1.15mm APIUT	6.5	28.1
0.64mm PIUT	8.6	37.7	1.27mm PIQC	4.2	19.4
0.64mm PIQL	9.4	41.4	1.27mm PEIQC	3.6	13.2
0.64mm PEIUT	7.3	26.4	Cat 5 / Cat 6	11.1	36.0
0.64mm CPIUT	8.5	30.5	CAD55	10.1	36.5
0.64mm CPFUT	7.2	25.4	0.4mm CPTIE	14.5	51.1

B3 Cable Losses at Higher Frequencies

Existing methods for modelling twisted pair cables needed extension to effectively model the behaviours of Australian cables at higher frequencies. The key observations from investigations were:

- Additional loss in transmission path due to crosstalk;
- Changes in crosstalk behaviour beyond the two-slope model; and
- Crosstalk behaviour in intra-binder and intra-cable crosstalk with pairs of the same twist ratio has a significantly different signature compared with other pair combination with non-integer twist lengths.

Models for attenuation and mean pair to pair FEXT and NEXT of 100m of each of a range of Australian cables are in Table 18 below. The basic attenuation model presented below accounts for losses due to crosstalk using a $K'f^2$ factor however it is worth noting that this effect is superseded at higher frequencies by crosstalk self-returning into the original pair and this model does not account for this effect. The basic models are as follows with f in MHz:

$$Attenuation\ (f) = \text{Attenuation}(1\text{MHz})\sqrt{f} + K'f^2 \tag{A1}$$

$$FEXTR\ (f) = \text{Max}\{0, \text{FEXTR}(1\text{MHz}) - 20 * \log_{10}(f) - pf\} \tag{A2}$$

$$NEXTA\ (f, 100m) = \text{NEXTA}(1\text{MHz}, 100\text{m}) - \text{Slope}_N * \log_{10}(f) - \left\{\text{if}(f > f_T)then\ Slope_2 * \log_{10}\left(\frac{f}{f_T}\right)else\ 0\right\} \tag{A3}$$

In addition, the Australian Communications Alliance codes characterise crosstalk using the 1% worst case FEXT power sum ratio and NEXT power sum attenuation from M disturbers at 1MHz. These power sums over M disturbing pairs may be obtained theoretically from the basic FEXTR and NEXTA models using the Wilkinson approximation (see the classic Bell system Technical Journal papers by N. A. Marlowe,[5] and by I. Nasell,[6].

$$FEXTPSR\ (f, M) = \text{FEXTPSR}(1\text{MHz}, M = 4) - 6 * \log_{10}\left(\frac{M}{4}\right) - 20 * \log_{10}(f) - pf \quad (A4)$$

$$NEXTPSA\ (f, M) = \text{NEXTPSA}(1\text{MHz}, M = 4) - 6 * \log_{10}\left(\frac{M}{4}\right) - \text{Slope}_N * \log_{10}(f) - \left\{\text{if}(f > f_T)then\ Slope_2 * \log_{10}\left(\frac{f}{f_T}\right)else\ 0\right\} \tag{A5}$$

The model parameters are derived from measurements that were performed on individual cables and on groups of cables within a 50mm PVC access pipe. Individual cable measurements include within unit (WU). Measurements between cables sharing a pipe are designated within pipe (WP). The mean attenuation and crosstalk parameters in dB for 100m of various cable types with full overlap are tabulated below, along with 1% power sum crosstalk adjusted to 4 disturbers.

TABLE 18

Attenuation and Crosstalk model parameters for some Australian cables

Cable Type	Pair Comb	Attenuation at 1 MHz (dB/100 m)	K'	FEXTR at 1 MHz	FEXTPSR at 1 MHz, 4d	p	NEXTA 1 MHz	NEXTPSA 1 MHz, 4d	Slope$_N$	f$_T$
CPFUT .4 10pr WU	45	1.9	0.00085	63	46.6	0.053	56	40.5	15	N/A
CPFUT .4 10pr WP	100	1.9	0.00085	92	75.4	0.21	91	75.5	15	7
PEIFLI .4 quad WP	6	1.9	0.00007	79	61.6	0.01	77	57.6	15	N/A
HT57 2pr WP bw-bw	28	1.8	0.000009	85	69.5	0	93	77.4	10	N/A
HT57 2pr WP rb-rb	28	1.56	0.00001	79.5	55.3	0.015	83	67.5	10	N/A
HT57 2pr WP rb-bw	28	1.68 mean	NA	108	92.4	0	114	98.5	15	N/A
Cat3 Riser 25pr WU	45	1.9	0.00012	70	50.9	0.016	68	49.6	15	100

APPENDIX

C TELSTRA PROPOSAL TO NRP FOR 7 NON-DEPLOYMENT CLASS SYSTEMS FOR C559

C1 Background

The complete Telstra submission is included here to demonstrate the Legacy System protection requirements that have been inherited from C559 and remain sufficient for compliance with the Legacy System protection requirements of this code.

The deemed compliance requirements of this code use slightly different masks for shaping signals at Lower NRPs. However the Deployment ranges within which each mask can be used remain as described in Tables 3 to 5 below, and illustrated in the Figures.

Appendix D includes additional rules for the optional selection of an additional 6dB DPBO PSD Mask defined in this Code.

C2 Submission for Registration of seven Non-Deployment Class Systems for ADSL2+ Mid-Span Feed Under CA Code C559

Philip Potter and Peter Cooke, Telstra, 3rd February 2012.

[NRP/76/07 Telstra Submission of 7 NDCS per CA C.559_2012 03 Feb 2012]

C.2.1   Introduction

Telstra proposes seven new Non-Deployment Class Systems (NDCSs) for registration under CA Code 559 and the provisions of Guideline 618. The proposed new NDCS all represent equivalence or reduction in power spectral density (PSD) from the usual Deployment Class 6h ADSL2+ transmitted PSD at all frequencies. Each is logically derived from the existing Deployment Class 6h by the addition of one of seven different linear filters to the downstream ADSL2+ transmitted signal.   The upstream transmitted signal is not modified and remains compliant with Equipment Class 6h. These new NDCS are intended for use in Deployment State A to reduce the ADSL2+ and ADSL signal PSD from a remote DSLAM in dual feed distribution areas.

This submission specifies Group A masks for the nominal transmit PSDs to be transmitted from the remote DSLAM. Furthermore, because the remote DSLAM may be connected to the remote Lower NRP (henceforth called the Midpoint Injection Location) through a dedicated tail cable, the description of each new NDCS necessarily includes a set of tail-cable attenuations with an associated set of acceptable ranges for attenuation from the exchange MDF (Highest NRP) to the Midpoint Injection Location. The only alternative to this approach would be to define a much larger number of NDCS (effectively one for each tail cable loss). This latter alternative has not been followed with this or previous mid-span feed solutions as it would be very cumbersome to administer.

CA C.559 Part 2 describes simulations to be performed for proposed NDCS to assess the degree of crosstalk interference they cause into the designated Basis Systems. Telstra has performed the necessary simulations using the CA Spectral Compatibility Tool (November 2011 Version with corrected cable attenuation data as in the currently agreed draft C.559 (2012)) with the crosstalk calculation templates obtained as required by 8.4.5 (1) of Part 1 of C.559 by subtracting the filter attenuation from the Group A mask for Deployment Class 6h. The simulation results have been used to develop the deployment rules given below. The simulations show that when the proposed systems are deployed in accordance with these rules they are spectrally compatible with (i.e. they do not cause Unacceptable Interference into) all Basis Systems under Deployment State A. The Basis Systems that are limiting for design of these NDCS are the ADSL and ADSL2+ Basis Systems defined in C.559.

C.2.2 Filter Description

The PSD templates used for crosstalk calculation are specified in the following format. Note that this submission uses ADSL2+ tones interchangeably with frequency which is equal to the tone index multiplied by 4.3125 kHz.

1. A 0.40 mm PIUT cable shaped attenuating pad of specified attenuation at 300 kHz defines the shaped filter attenuation out to tone T1. The standard ADSL2+ Class 6h template is attenuated by a specified loss of the standard 0.40 mm PIUT cable as defined in C.559 Part 2, Section 5.1.
2. A flat psd at -85 dBm/Hz from tone T1 to tone T2.
3. A linear steep upward slope of less than 1.5 dB/tone from tone T2 to tone T3 where the PSD is -60 dBm/Hz.
4. A flat PSD at -60 dBm/Hz to tone 512.

Note that the 12 dB pad never reaches -85 dBm/Hz and turns to the steep upward slope at tone 425 at -81.2 dBm/Hz.

Because these constitute linearly filtered versions of the ADSL2+ Class 6h templates in C.559 Part 3, Appendix M, G.618 specifies that the Group B compliance mask for Deployment is based on the same linear filtering of the ADSL2+ Group B mask (i.e. 3.5 dB higher than the specified Group A masks), to allow for equipment tolerances.

Pad → Parameter	0.869 km	1.3034 km	1.5207 km	1.738 km	2.0275 km	2.2447 km	2.462 km
Pad Loss	12	18	21	24	28	31	34
T1	na	321	282	246	186	154	129
T2	na	403	383	323	273	223	193
T3	440	420	400	340	290	240	210

Table C1. PSD Template description (Group A masks) for new NDCS that meet Deployment Class 6h. Note that the 12 dB pad never reaches -85 dBm/Hz and the PSD turns directly from the attenuated Class 6h template to the 1.5 dB/tone upward slope at tone 425 at -81.2 dBm/Hz.
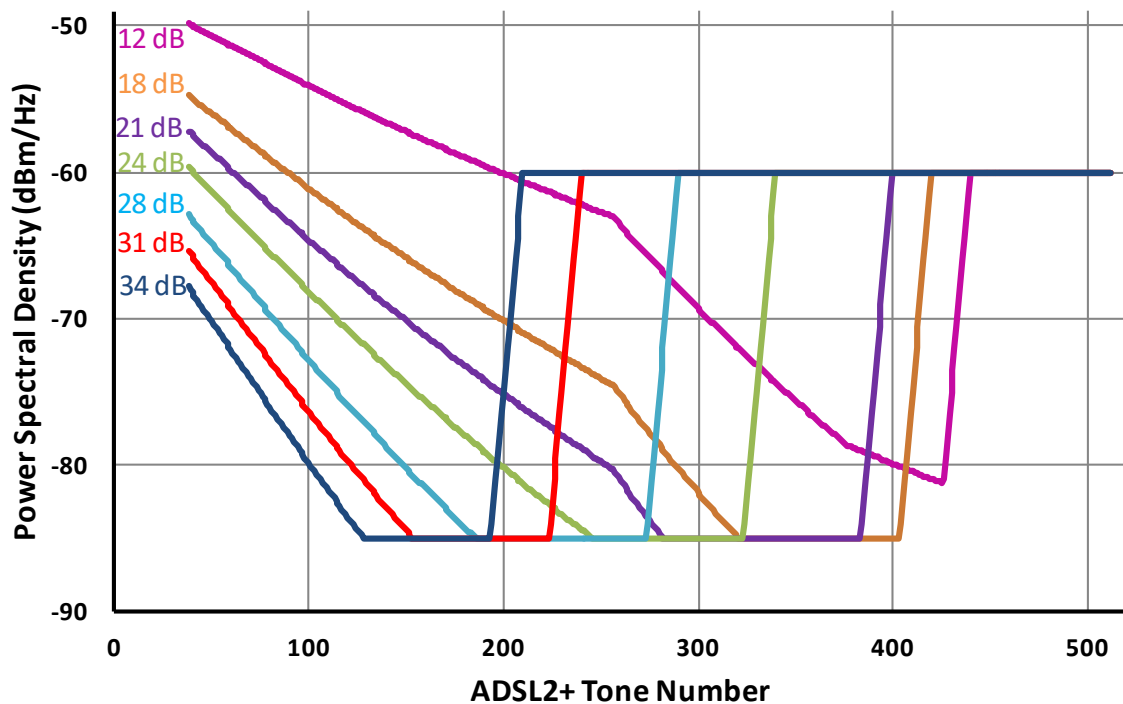
Fig. C1. Nominal Group A PSD Templates for 7 NDCS. Note that Group B compliance masks are 3.5 dB higher.

While the shaper descriptions above cover only the PSD in the ADSL2+ downstream band, the requirement to be a filtered version of the ADSL2+ PSD means that the out of band PSD of all proposed NDCS must still satisfy the mask of Deployment Class 6h. In practice, the out-of-band PSD would be considerably below that mask to avoid any step in the PSD.

C.2.3   Derived Compliance Masks

The resulting Group B compliance mask for the in-band downstream PSD of each of the proposed NDCS is obtained by adding 3.5 dB to the template or Group A mask specified in Table C1. The upstream compliance masks are not modified and remain as in Equipment Class 6h.

The defined Group A masks or templates represent the nominal design PSD from the Midpoint Injection Location and are the Group A crosstalk calculation templates for the NDCS. Where a dedicated tail cable is present, the crosstalk calculation templates for downstream crosstalk sources at the Midpoint Injection Location are further reduced by the standard 0.40mm PIUT cable shaped tail-cable attenuation at all frequencies.

C.2.4   Simulations required by C.559

CA code C.559 requires that for Non-Deployment-Class Systems:

1. The transmit PSD Mask must not cause Unacceptable Excess Power.
2. The proposed NDCS must not cause Unacceptable Interference into any Basis System.

Because the proposed masks and templates represent a reduction in psd from those for Deployment Class 6a, they cannot cause Unacceptable Excess Power. For the same reason, the interference from these systems into the upstream of any single pair symmetric Basis System (i.e. ISDN, HDSL, SHDSL) is reduced and those Basis Systems cannot suffer unacceptable NEXT interference from the downstream ADSL2+. Because FEXT is generally much lower than NEXT, the slightly higher shaped FEXT from the Midpoint Injection Location is much lower than the limiting NEXT from other like symmetric systems at the customer end of the line, and therefore does not impact unacceptably on those symmetric Basis Systems. These assertions have been confirmed by testing with the CA spectral compatibility tool.

The requirements not to cause Unacceptable Interference into the remaining ADSL2+, ADSL and E1 Basis Systems is assessed using the CA Spectral Compatibility Tool. "Unacceptable Interference into a Basis System" requirements of the code are tested with successive trial distances at 0.1 km intervals between the Highest NRP and the proposed Midpoint Injection Location. This exhaustive process establishes the full range of distances from the Highest NRP at which each proposed new NDCS may be deployed without infringing the Deployment State A benchmark performances of any Basis System.

To test for Unacceptable Interference, it is necessary to use the CA Spectral Compatibility Tool to determine the performance of the Basis System (e.g. rate vs range of an ADSL2+ Basis System, margin at specified range of an SHDSL Basis System, etc) when subject to interference from:

- 4 Basis systems from the Highest NRP. The transmitted PSDs for these Basis System disturbers are defined by the Templates (Group A requirements) in the simulations. E.g. For the ADSL Basis System, the ADSL Class 6a Upstream Group A template.
- 4 proposed NDCS operating from the Midpoint Injection Location (possibly through a tail cable). The transmitted PSDs for these disturbers are defined by the proposed NDCS Downstream Group A Template of Figure C1.

Both sets of disturbers and the disturbed system are assumed to have their customer ends co-located. The assessment process is repeated for the full range of possible tail cable lengths.

C.2.5   Results of Simulations

In the deployment ranges provided below, the shapers have been determined to satisfy both CA Code 559 requirements 1 and 2 as set out in Section 4 above. They have been obtained from simulations performed by Telstra using the latest version of the CA Spectral Compatibility tool (Nov 2011), with the uxpower tab enhanced to represent the proposed shapers.

With zero length tail cable between the RIM and the pillar, the requirement not to cause Unacceptable Interference into any Basis System is met when the distance (on the CA reference cable 0.40 PIUT) from the Highest NRP to the Midpoint Injection Location of the proposed NDCS is within the acceptable ranges given in Table C2. These ranges correspond to the shorter upper bound and the longer lower bound (i.e. the more stringent bound) of the two deployment limits calculated for the ADSL and ADSL2+ Basis Systems. Table C2 also specifies those limits as attenuations applicable to all cable types. Simulations at other lengths within the compliant regions have been performed at 0.1 km intervals to ensure that there are no other non-compliant ranges.

Shaper	Primary Range	(in dB at 300 kHz)	Additional Range	(in dB at 300 kHz)
None	0 to 0 km	0 to 0	n/a	n/a
12 dB	0 to 1.04 km	0 to 14.36	n/a	n/a
18 dB	0 to 1.75 km	0 to 24.17	n/a	n/a
21 dB	1.50 to 2.02 km	20.72 to 27.90	0 to 0.75	0 to 10.36
24 dB	1.78 to 2.30 km	24.58 to 31.76	0 to 0.63	0 to 8.70
28 dB	2.00 to 2.71 km	27.62 to 37.43	0 to 0.61	0 to 8.42
31 dB	2.40 to 3.07 km	33.14 to 42.40	0 to 0.61	0 to 8.42
34 dB	2.75 to ∞ km	37.98 to ∞	0 to 0.61	0 to 8.42

Table C2. Compliant ranges from the Highest NRP for proposed NDCS, with zero tail cable length. Conversion from km of 0.4mm PIUT cable to dB at 300 kHz uses 13.81 dB/km.

The authors' results in Table C2 have been confirmed by Dr Bruce Clarke of Telstra using his independent spectral compatibility computation tool that was used in the development of the VDSL2 drafts in 2009.

Simulations of interference from the shaped ADSL2+ systems to the E1-HDB3 Basis System were performed for the case of 4 adjacent-unit E1 NEXT disturbers (within-unit E1 NEXT disturbers are not permitted within the Telstra design rules which separate the Go and Return directions into separate cable units), 4 within-unit E1 FEXT disturbers and 4 within-unit disturbers of each NDCS type. The Spectral Compatibility Benchmark of 6 dB margin at 1 km was significantly exceeded (by more than 3.5 dB) for all 7 NDCS in the worst case of co-located exchange and customer ends. Therefore unit separation from E1 systems is not required.

C.2.6   Consideration for design with tail cables from Remote DSLAMs to Midpoint Injection Locations

In many dual feed cases, the remote equipment housing in which the proposed NDCS are to be installed is connected to a cross connect location (e.g. a pillar) by a dedicated tail cable up to several hundred metres long and only shares cabling with exchange fed systems beyond that cross connect location. As this tail cable attenuates the signal from the NDCS before it is injected into the shared cabling from the exchange, simulations of these cases have also been performed to determine what design rules should be used with tail cables present. According to the strict definition of the code, each tail-cable loss would define a separate NDCS, but in the interests of practical administration (as was accepted for the earlier NDCS describing ADSL pads), Telstra proposes the use of the same single set of NDCS with acceptable deployment ranges that are a function of the tail-cable attenuation. This proposal leads to the specification of a set of acceptable deployment ranges covering all tail-cable lengths for each new NDCS.

These sets of ranges are specified in tables 3 to 5 below and shown in Figure C2. For each table-cable length there is a primary range for which the lower bound on loss from the Highest NRP to the Midpoint Injection Location is given in Table C3 and the upper bound to that loss in Table C4. For some shapers and tail-cable losses, there is an additional compliant loss range starting at 0 dB and finishing at the value given in Table C5.

Tail Loss dB	0 dB none	12 dB + mask 440	18 dB + mask 420	21 dB + mask 400	24 dB + mask 340	28 dB + mask 290	31 dB + mask 240	34 dB + mask 210
0	0	0	0	20.72	24.58	27.62	33.14	37.98
1	0	0	0	20.72	24.17	27.62	33.14	37.43
2	0	0	0	20.58	23.48	27.48	33.01	37.15
3	0	0	0	0	23.48	27.34	32.87	37.01
4	0	0	0	0	23.34	27.07	32.73	36.87
5	0	0	0	0	23.20	25.96	32.18	36.46
6	0	0	0	0	22.92	25.41	31.21	35.08
7	0	0	0	0	21.13	24.17	30.66	32.59
8	0	0	0	0	0	0	0	31.76

Table C3. Lower bound on acceptable loss from Highest NRP in the primary range. For tail cables of loss 9 dB or higher, the lower bound is 0 dB for all shapers.

Tail Loss dB	0 dB none	12 dB + mask 440	18 dB + mask 420	21 dB + mask 400	24 dB + mask 340	28 dB + mask 290	31 dB + mask 240	34 dB + mask 210
0	0.00	14.36	24.17	27.90	31.76	37.43	42.40	
1	2.49	16.57	25.41	29.14	33.01	39.08	45.85	
2	3.73	19.20	26.65	30.52	34.53	40.88		
3	5.11	20.58	27.90	31.76	35.91	43.23		
4	6.35	21.82	29.14	33.01	37.43	45.85		
5	7.60	23.06	30.52	34.53	39.22			
6	8.84	24.17	31.76	35.91	40.88			
7	10.08	25.41	33.01	37.43	43.23			
8	11.46	26.65	34.53	39.22	45.85			
9	12.71	27.90	35.91	40.88				
10	14.22	29.14	37.43	43.23				
11	15.47	30.52	39.08	45.85				

12	16.71	31.76	40.88					
13	17.95	33.01	43.23					
14	19.20	34.53	45.85					
15	20.58	35.91						
16	21.82	37.43						
17	23.06	39.22						
18	24.17	40.88						
19	25.41	43.23						
20	26.65	45.85						
21	27.90							
22	29.14							
23	30.52							
24	31.76							
25	33.01							
26	34.53							
27	35.91							
28	37.43							
29	39.36							
30	40.88							
31	43.23							
32	45.85							

**Table C4. Upper bound on acceptable loss from Highest NRP in the primary range.
Where no bound is shown, there is no upper bound. For tail cables of loss 33 dB or higher
with all shapers, and for the 34 dB shaper at all tail cable losses, there is no upper bound.**

Tail Loss dB	0 dB none	12 dB + mask 440	18 dB + mask 420	21 dB + mask 400	24 dB + mask 340	28 dB + mask 290	31 dB + mask 240	34 dB + mask 210
0				10.36	8.70	8.42	8.42	8.42
1				11.60	9.94	9.67	9.67	9.67
2				12.98	11.19	10.91	10.91	10.91
3					12.57	12.29	12.15	12.15
4					13.95	13.53	13.53	13.53
5					15.33	14.91	14.91	14.91
6					16.85	16.43	16.43	16.43
7					19.33	18.51	18.37	18.37
8								26.79

Table C5. Upper bound on acceptable loss from Highest NRP in the additional range. The lower bound of the additional range is zero. Blank entries indicate that no additional range exists. For tail cables of loss 9 dB or higher, the primary range starts at zero and no additional range is required.
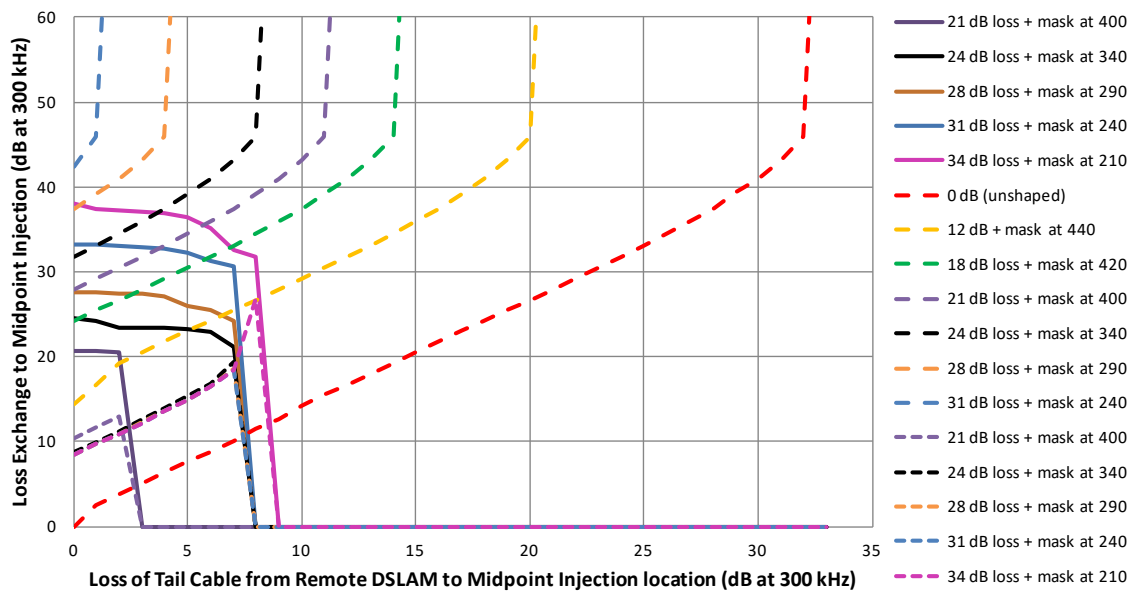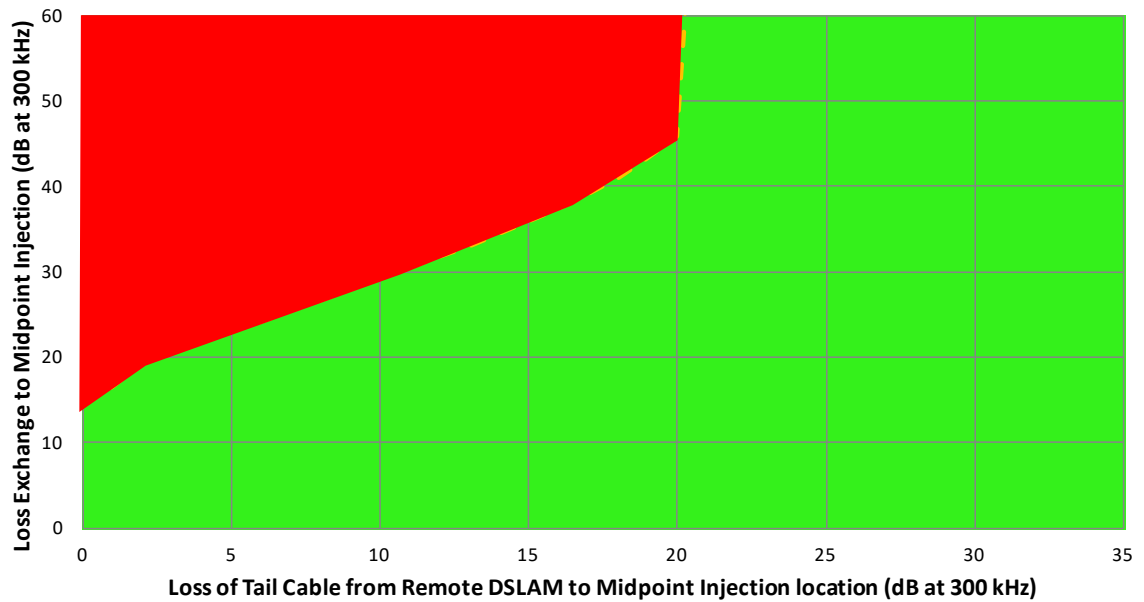

Fig. C2. Deployment limits for the Midpoint Injection Location from the Highest NRP for the 7 NDCS vs Tail-Cable Attenuation. The dashed lines represent upper limits, while the solid line is the lower limit for the primary range.

For avoidance of misunderstanding the acceptable deployment regions are shown in green on the following illustrative plots.
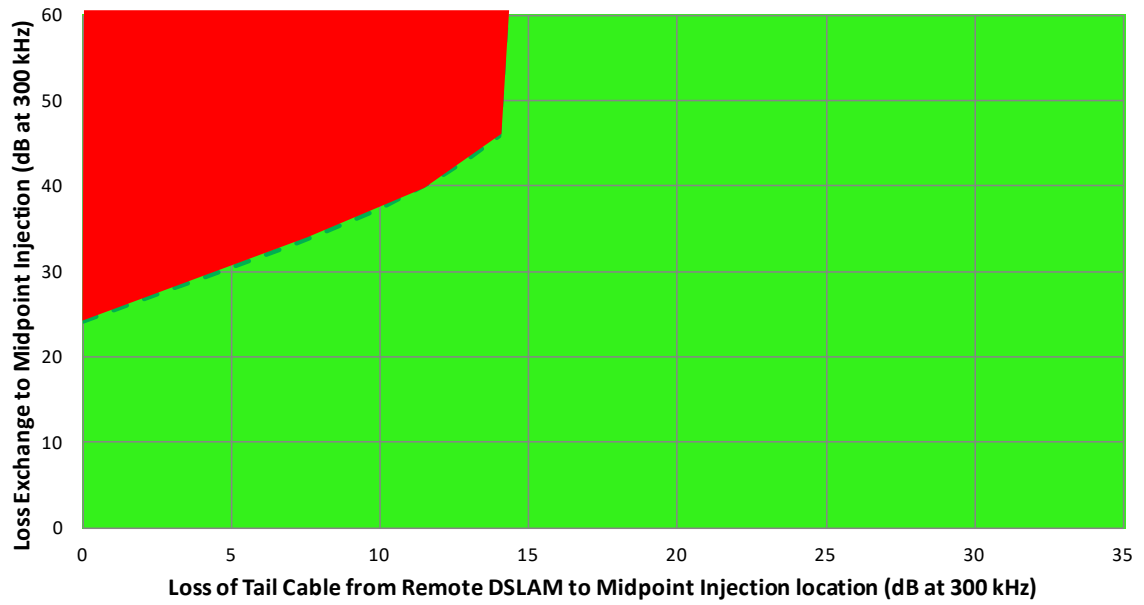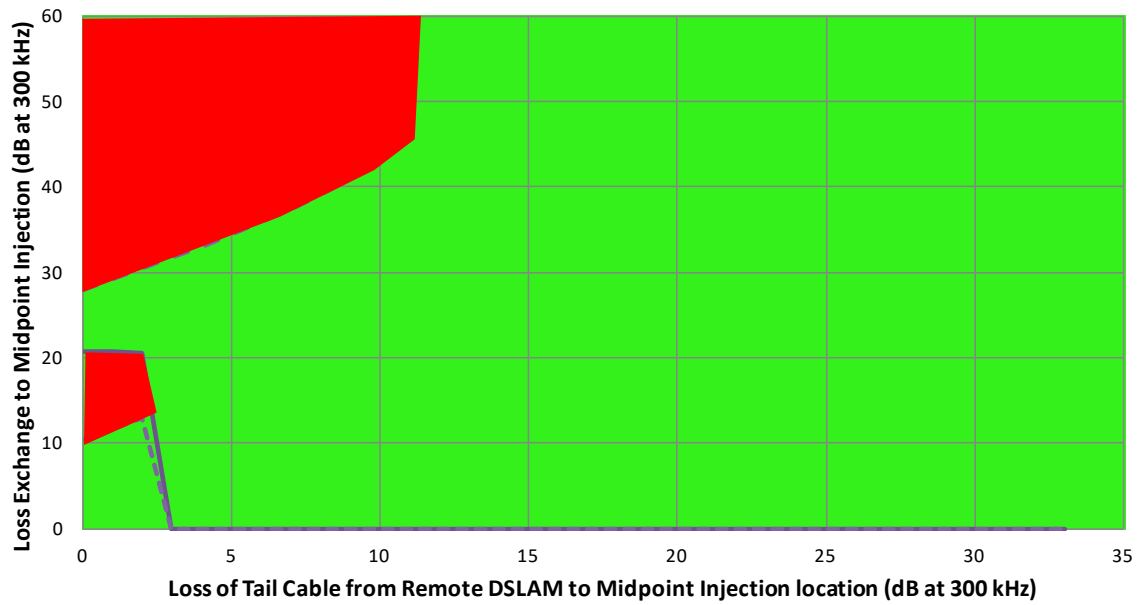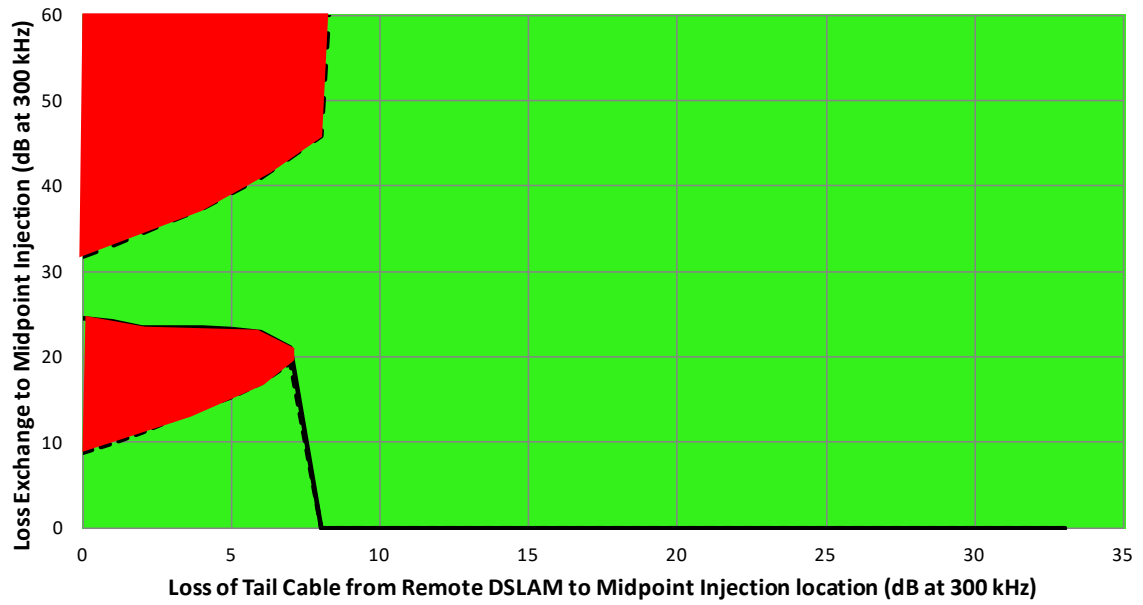
No Shaper

12 dB Shaper

18 dB Shaper

Loss Exchange to Midpoint Injection (dB at 300 kHz) vs Loss of Tail Cable from Remote DSLAM to Midpoint Injection location (dB at 300 kHz)

21 dB Shaper

Loss Exchange to Midpoint Injection (dB at 300 kHz) vs Loss of Tail Cable from Remote DSLAM to Midpoint Injection location (dB at 300 kHz)
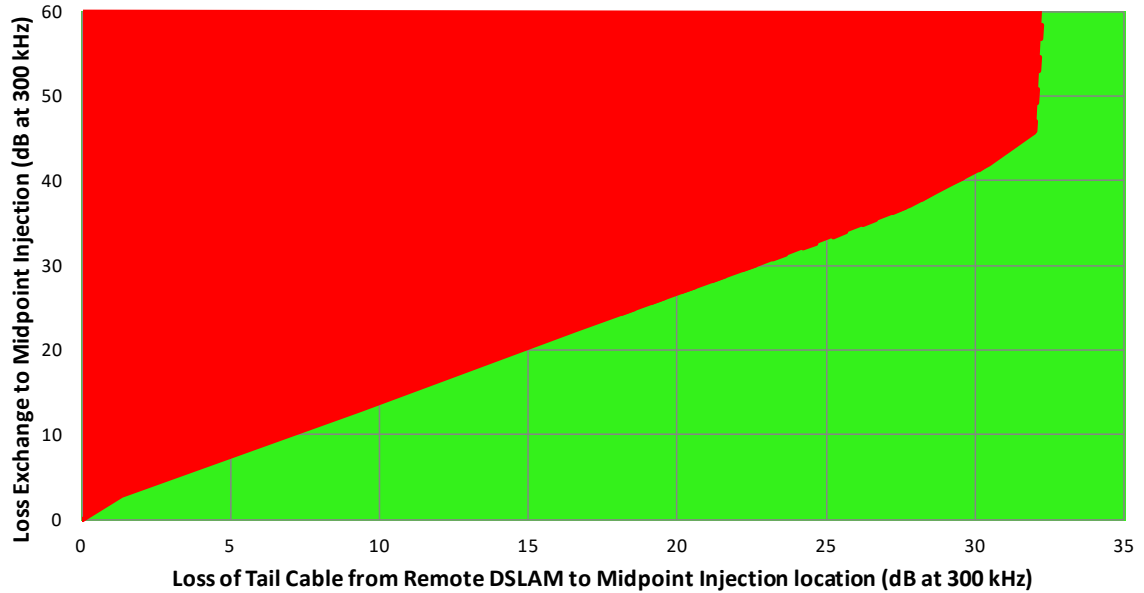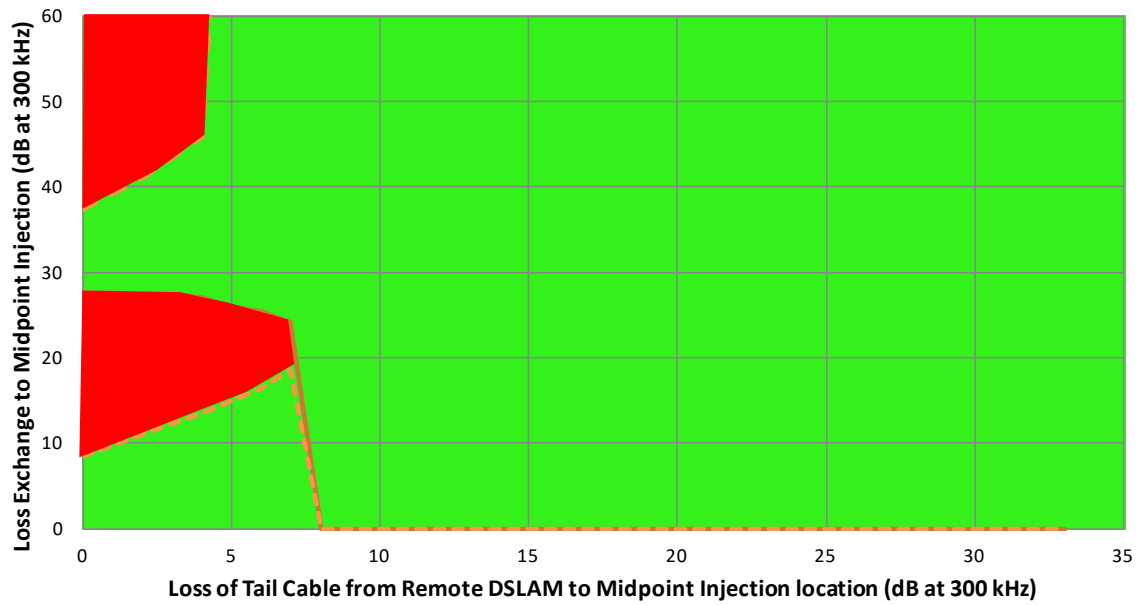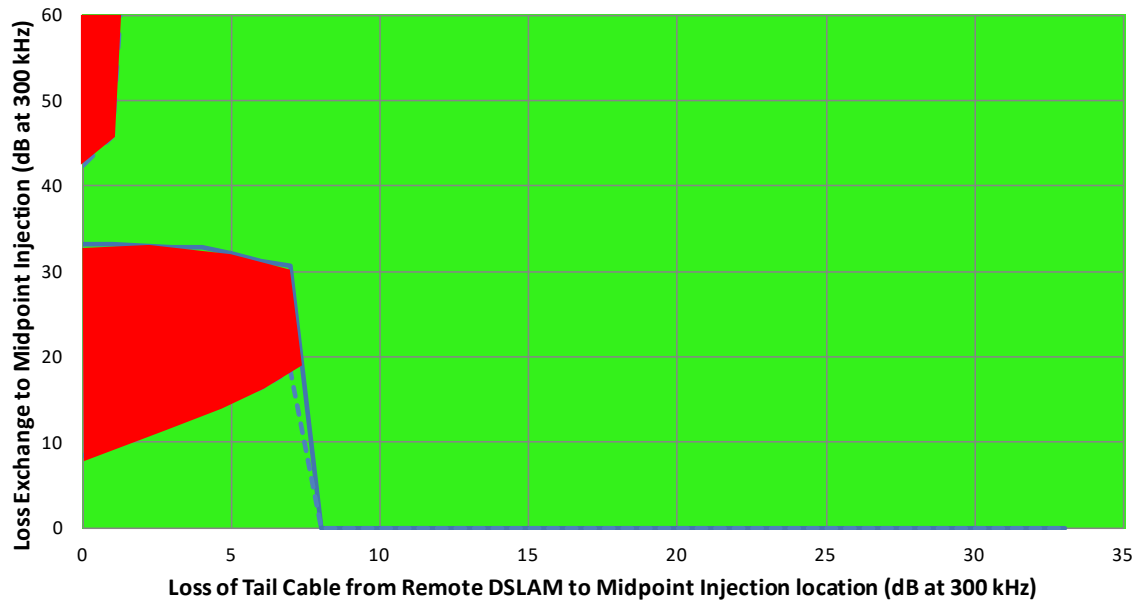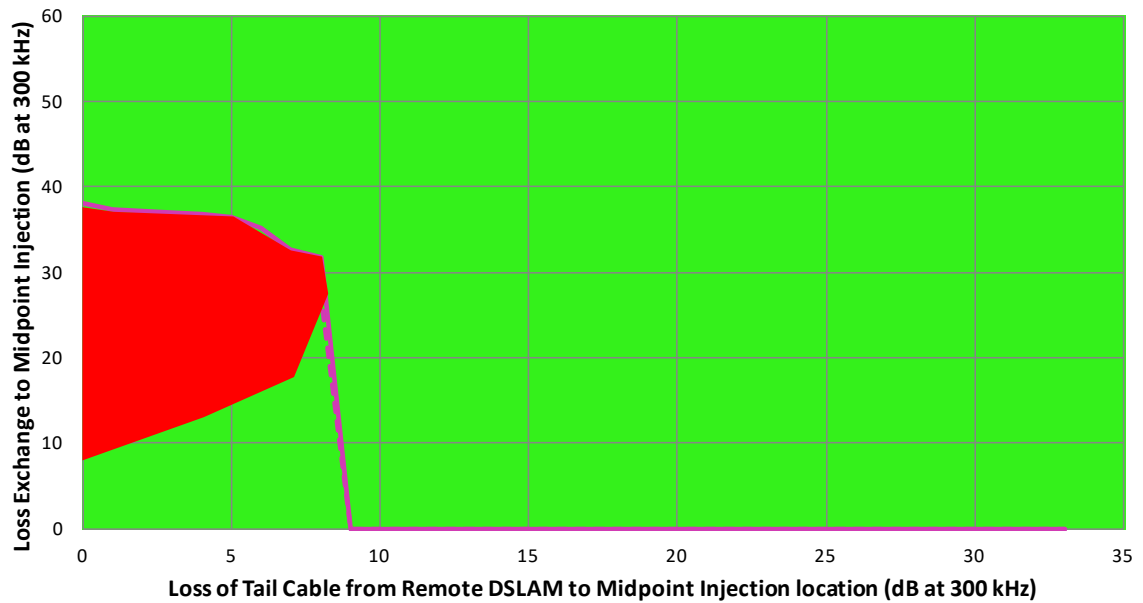
24 dB Shaper

28 dB Shaper

31 dB Shaper

34 dB Shaper

Fig. C3. 8 plots of compliant (green) and non-compliant (red) deployment regions for the case of no shaper and the 7 proposed shapers (informative illustrations only).

In applying these deployment limits, the service Provider must ensure that each midpoint injection location has a compliant shaper setting, and if a common shaper is used for all ports on the remote DSLAM then all midpoint injection locations fed from that DSLAM must be compliant with that common shaper selection.

C.2.7   Conclusions

The 7 proposed PSD shaper NDCSs have been tested against all necessary Basis System Benchmarks using the CA Spectral Compatibility tool with corrected cable attenuation settings (Nov 2011) as in the updated draft C.559 (2012). With deployment limits defined by the ranges of Table C2 (for no tail cable) and Tables C3 to C5 (with tail cable), and based on the most limiting Basis System in each case, the shapers have been shown to comply with requirements of CA C.559 (2012). Therefore Telstra applies to have the 7 shapers, as defined by Table C1 using the attenuation vs frequency of the standard 0.40mm PIUT cable, listed as NDCS by Communications Alliance.

APPENDIX

D   DEPLOYMENT RULES FOR AN ADDITIONAL 6dB DPBO SHAPER

PROPOSAL FOR A NEW 6DB SHAPER IN C658

1. Introduction

nbn requests the registration of a 6dB Shaper, defined in section 2 below. The proposed PSD has lower power levels than Deployment Class 6h ADSL2+ under C.559. The upstream PSD is not modified, so remains compliant with Equipment Class 6h.

The proposed 6dB shaper is intended to complement the seven existing NDCS ADSL2+ shapers defined under C559 (with pad values 12dB, 18dB, 21dB, 24dB, 28dB, 31dB and 34dB), and to be included as an additional shaper option in draft C658. The existing seven NDCS ADSL2+ shapers were submitted by Telstra to CA in Mar 2012. For ease of comprehension and compilation, **nbn** has adopted the same set of tables as used by Telstra in its original submission, to define the new 6dB shaper.

The original Telstra shapers were designed to respect a constraint in the G.993.5 ADSL2+ ITU-T Recommendation which stipulated that the upward ramp at the high frequency end of the DPBO shaper should not return to a power level higher than -60dBm/Hz. This restriction does not exist in the G993.2 VDSL2 Recommendation, and so the proposed C.658 shapers and this 6dB shaper return to the template mask at the high frequency side.

The proposed 6dB shaper is intended to be used in deployments of Next Generation Broadband Systems deployed under or to be compatible with draft industry Code C.658, to reduce PSD emitted in the ADSL2+ band from a Next Generation Broadband System in dual or multiple feed distribution areas. The 6dB shaper may, for example, be used by a basement system during a Coexistence Period, to avoid causing unacceptable interference to other legacy or next generation broadband systems deployed and higher network reference points.

The DSLAM on which the proposed 6dB shaper is configured may be connected to the remote Lower NRP through a dedicated tail cable (a cable connecting the DSLAM to the lower network reference point which is not spectrally shared with another DSLAM). Table D2 has been provided for acceptable ranges of tail-cable attenuation and associated exchange MDF (highest NRP) to the Midpoint Injection Location attenuation.

Although this shaper is not being proposed under CA C.559 Part 2, it is similar in nature to the seven shapers Telstra proposed under that Code. Shapers proposed under CA C.559 Part 2 require analysis of interference into the C.559 Basis Systems. **nbn** has undertaken the necessary simulations using the CA Spectral Compatibility Tool (November 2011 Version with corrected cable attenuation data as in the currently agreed draft C.559 (2012)) with the crosstalk calculation templates obtained as required by 8.4.5 (1) of Part 1 of C.559. The proposed deployment rules in Table D2 below were created to ensure that the 6dB pad does not cause unacceptable interference into any of the Basis Systems under Deployment State A. The results of these simulations indicate the proposed 6dB shaper would be also be compatible under C.559.

2. Filter Description

The proposed 6dB Shaper is defined by a PSD Template defined as follows, and shown in figure 1.

2.1   The downward slope from Tone 32 to Tone 506 is calculated by the ADSL2+ Class 6h template attenuated by the cable loss of a 6dB length of 0.40 mm PIUT cable (measured at 300 kHz) as defined in C.559 Part 2, Section 5.1.

2.1.1   the downward slope turns into a steep upward slope at tone 506, where the PSD is -68 dBm/Hz. The steep upward slope from tone 506 to tone 512 is at 2.76 dB/tone. Tone 512 is full power -51.5 dBm/Hz.
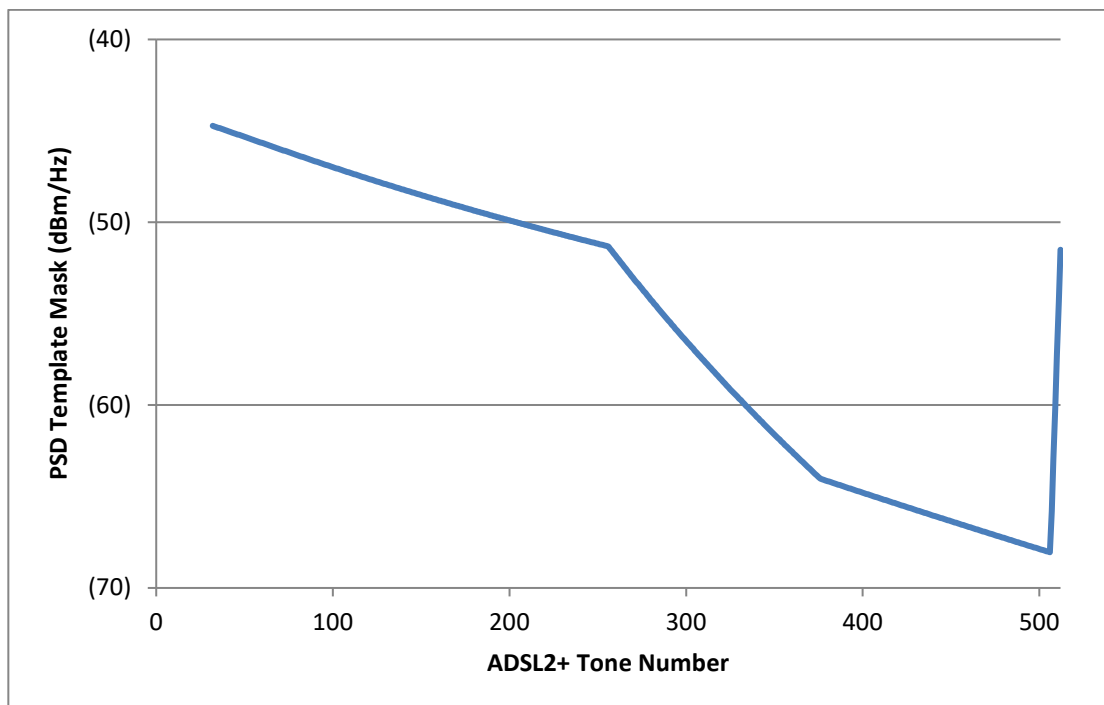

Fig. D1.   PSD Template for 6dB Shaper at Remote DSLAM. Group B compliance mask and PSD Mask are both 3.5 dB higher.

3. Simulations required by C559

3.1   C.559 requires that the proposed transmit PSD mask must not cause unacceptable excess power. As the proposed PSD is lower than Deployment Class 6h, it cannot cause unacceptable excess power.

3.2   C.559 requires that the proposed NDCS must not cause unacceptable interference into a Basis System. The interference from the proposed 6dB shaper into the upstream of any single pair symmetric Basis System (ISDN, HDSL, SHDSL) is less than caused by Class 6h. Therefore, these Basis Systems cannot suffer unacceptable NEXT interference from the proposed 6dB shaper. These assertions have been confirmed by testing with the CA spectral compatibility tool.

The requirements not to cause unacceptable interference into the remaining ADSL2+, ADSL and E1 Basis Systems is assessed using the CA Spectral Compatibility Tool.

"Unacceptable Interference into a Basis System" requirements of the code are tested with successive trial distances at 0.1 km intervals between the highest NRP and the proposed Midpoint Injection Location.

To test for unacceptable interference, **nbn** used the CA Spectral Compatibility Tool to determine the performance of the Basis System when subject to interference from:

- 4 Basis systems from the highest NRP
- 4 x proposed NDCS operating from the Midpoint Injection Location (possibly through a tail cable).

All disturber and disturbed customer ends are co-located. The assessment process is repeated for the full range of possible tail cable lengths.

4. Results of Simulations

The proposed 6dB shaper has been determined to satisfy both CA Code 559 requirements described in 3.1 and 3.2 above, through simulations performed by nbn using the latest version of the CA Spectral Compatibility tool (Nov 2011).

With zero tail cable between the Remote DSLAM and the pillar, the allowed deployment ranges are specified in Table D1. Simulations at 0.1 km intervals have confirmed there are no other non-compliant ranges.

Shaper	Primary Range	(in dB at 300 kHz)	Additional Range	(in dB at 300 kHz)
6 dB	0 to 0.570 km	0 to 7.99	n/a	n/a

Table D1. Compliant ranges from the highest NRP for proposed NDCS, with zero Remote DSLAM tail cable length.

Simulations of interference from the shaped ADSL2+ systems to the E1-HDB3 Basis System were performed for the case of 4 adjacent-unit E1 NEXT disturbers (within-unit E1 NEXT disturbers are not permitted within the Telstra design rules which separate the Go and Return directions into separate cable units), 4 within-unit E1 FEXT disturbers and 4 within-unit disturbers of the proposed NDCS. The Spectral Compatibility Benchmark of 6 dB margin at 1 km was significantly exceeded in the worst case of co-located exchange and customer ends. Therefore, unit separation from E1 systems is not required. Given that the 6dB shaper has a maximum deployment range of only 0.57 km, E1 noise margins will be even greater than the 1km test case.

5. Tail cables from Remote DSLAMs to Midpoint Injection Locations

In many dual feed cases, the remote equipment housing in which the proposed NDCS are to be installed is connected to a cross connect location (e.g. a pillar) by a dedicated tail cable up to several hundred metres long and only shares cabling with exchange fed systems beyond that cross connect location.

Acceptable deployment ranges are specified in Table D2 below. For each dedicated tail cable length, there is a range of bounds on loss from the highest NRP to the Midpoint Injection Location. There is no equivalent of Table D2 in Appendix C.

TABLE D2

Upper bound on acceptable loss from highest NRP in the primary range

Tail loss (dB)	Upper Bound (dB)	Tail loss (dB)	Upper Bound (dB)	Tail loss (dB)	Upper Bound (dB)
0	7.99	9	20.58	18	31.76
1	9.22	10	21.82	19	33.01
2	10.40	11	23.06	20	34.53
3	11.60	12	24.17	21	35.91
4	12.85	13	25.41	22	37.43
5	14.10	14	26.65	23	39.22
6	14.36	15	27.90	24	40.88
7	16.57	16	29.14	25	43.23
8	19.20	17	30.52	26	45.85

NOTES:

1. For tail cables with loss 27 dB or higher, there is no upper bound.

2. The 6dB Shaper has a lower bound of 0 km for all dedicated tie cable lengths.

3. the 6dB Shaper has no additional upper deployment range.

6. Conclusions

nbn has simulated the proposed 6dB Shaper against all necessary Basis System Benchmarks using the CA Spectral Compatibility tool with corrected cable attenuation settings (Nov 2011) as in the updated draft C.559 (2012). Within the Deployment limits defined Table 2 (for no tail cable) and Tables 3 to 4 (with tail cable), the 6dB shaper has been shown to comply with requirements of CA C.559 (2012).

APPENDIX

E TECHNICAL DATA ON CABLES AND CROSSTALK LEVELS (FROM APPENDIX A TO G671)

1. Broadband Forum (BBF) contribution from nbn

17.1.1 **nbn** made a contribution to the PhyTX group within the Broadband Forum for amending TR-285i2 - Broadband Copper Cable Models to include Australian cable models.

17.1.2 The list of cables within the contribution was not completely published in *TR-285 – Broadband Copper Cable Models Issue 2, Amendment 1* as some cables have already had extensive study and are already well-known.

17.1.3 For completeness in this text, please find below the equations used and parameters determined for each cable type from the study (see Table 1).

TABLE 19
Cable Characteristics

Cable type	Pair Comb	Atten 1MHz	K'	FEXTR 1 MHz	FEXTPSR 1 MHz,4d	p	NEXTA 1MHz	NEXTPSA 1MHz,4d	SlopeN	f$_r$	Slope2
CPFUT .4 10pr WU	45	1.9	.00085	63	46.6	.053	56	40.5	15	N/A	0
CPFUT .4 10pr WP	100	1.9	.00085	92	75.4	.21	91	75.5	15	7	10
PEIFLI .4 quad WP	6	1.9	.00007	79	61.6	.01	77	57.6	15	N/A	0
HT57 2pr WP bw-bw	28	1.8	.000009	85	69.5	0	93	77.4	10	N/A	0
HT57 2pr WP rb-rb	28	1.56	.00001	79.5	55.3	.015	83	67.5	10	N/A	0
HT57 2pr WP rb-bw	28	1.68 mean	NA	108	92.4	0	114	98.5	15	N/A	0
Cat3 Riser 25pr WU	45	1.9	.00012	70	50.9	.016	68	49.6	15	100	10
Cat 5e WP	6	2.1	.000005	94	74.3	0	98	82.3	15	N/A	0
Cat 6 WP	6	2.0	0	98	78.3	0	103	85.3	15	N/A	0

NOTES: 1. CPFUT means 'Cellular Polyethylene Filled Unit Twin'; PEIFLI means 'Polyethylene Insulated Filled Lead In'.

2. 'WU' means 'within unit' (i.e. within the same unit (or binder) of a cable);

'WP' means 'within pipe' (i.e. between separate cables within the same cable bundle)

3. 'bw' means 'blue white', 'rb' means 'red black'.

PARTICIPANTS

The Working Committee that developed the Code consisted of the following organisations and their representatives:

Organisation	Membership	Representative
ACCC	Non-Voting	James Park
ACMA	Non-Voting	Cuong Nguyen
Adtran Networks	Voting	Ben Liew
Adtran Networks	Non-Voting	Alex Grigoruk
Gigacomm	Voting	Wayne Crace
Gigacomm	Non-Voting	Andrew Buckis
Gigacomm	Non-Voting	Rowena Jarvis
nbn	Voting	Stefan Keller-Tuberg
nbn	Non-Voting	Nathan Stathis
nbn	Non-Voting	Peter Burr
Netcomm Wireless	Voting	Anitha Parthasarathy
Nokia	Voting	Mickey Vucic
Nokia	Non-Voting	Bruce Orr
Nokia	Non-Voting	Evan Stanbury
Telstra	Voting	Geoff Gerrand
Telstra	Non-Voting	Giulio Consiglio
TPG Telecom	Voting	Stephanie Phan
TPG Telecom	Non-Voting	Selvan Eswaralingam
Individual	Non-Voting	Phil Potter

This Working Committee was chaired by Peter Cooke. James Duck of Communications Alliance provided project management support.

Communications Alliance was formed in 1997 to provide a unified voice for the Australian communications industry and to lead it into the next generation of converging networks, technologies and services.

In pursuing its goals, Communications Alliance offers a forum for the industry to make coherent and constructive contributions to policy development and debate.

Communications Alliance seeks to facilitate open, effective and ethical competition between service providers while ensuring efficient, safe operation of networks, the provision of innovative services and the enhancement of consumer outcomes.

It is committed to the achievement of the policy objective of the *Telecommunications Act 1997* - the greatest practicable use of industry self-regulation without imposing undue financial and administrative burdens on industry.