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Evaluation of the proposal to allow VDSL2 from the local exchange (EVDSL) in Ireland

Technical evaluation of the CLFMP amendment proposal

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Contents

Abbreviations

ADSL	Asymmetric DSL
CPE	Customer Premises Equipment
CLFMP	Copper Loop Frequency Management Plan
CVDSL	Cabinet-launched VDSL
DP	Distribution point
DS	Downstream
DSL	Digital Subscriber Line
DSLAM	DSL Access Multiplexer
EL-FEXT	Equal Level FEXT
EOC	Embedded Operations Channel
ES	Errored Second
EVDSL	Exchange launched VDSL
FEXT	Far-end crosstalk
ITU	International Telecommunications Union
LEX	Local Exchange
LLU	Local Loop Unbundling
NDR	Net Data Rate
NM	Noise Margin
NEXT	Near-end crosstalk
RI	Re-Initialisation
SLU	Sub Loop Unbundling
SRA	Seamless Rate Adaptation
US	Upstream
UPBO	Upstream Power Back-Off
VDSL	Very high bit rate Digital Subscriber Line (refers to VDSL2, the ITU G993.2 standard)
xDSL	Generic DSL, used to describe any form of DSL

1 Introduction

1.1 Background and goal of this evaluation

Eircom wishes to deploy VDSL2 from the local exchange (“EVDSL”). Currently, the Copper Loop Frequency Management Plan (CLFMP) does not allow EVDSL[2]. Eircom has proposed an amendment to the CLFMP to allow EVDSL, arguing that this will not have a negative impact existing services in the copper plant [1]. The copper plant is schematically drawn in figure 1.

Other operators contradict Eircom, and raise concerns on possible negative impact, specifically impact on VDSL2 deployed from the cabinet (“CVDSL”).

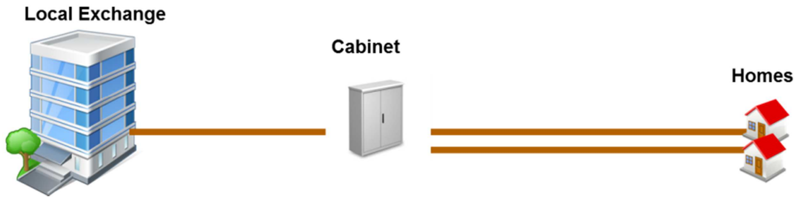

Fig 1 schematic representation of the Irish access network, with Exchange-fed and cabinet fed xDSL lines to the homes. In the current CLFMP, VDSL2 is only allowed to be deployed from the cabinet (CVDSL).

<u>Goal of this project:</u>
To provide expert analysis on operators’ submissions to the Information Notice published by ComReg on 7 July 2014 [7].

The central question in this evaluation is: Will EVSDL deployment cause negative impact on CVDSL deployment?

1.2 Approach followed in this evaluation

In this evaluation we will focus on the central question: Does EVDSL have negative impact on CVDSL performance? First (chapter 2), a qualitative analysis will describe the possible mechanisms and provide some insights in the quantitative effects.

The analysis is then continued (chapter 3) by examining the outcome of the lab and field trials with the data provided by Eircom via ComReg.
As part of this examination, methodology and approach of the lab and field tests are analysed.

The third step (chapter 4) is to compare the proposed CLFMP with the CLFMPs in other European jurisdictions where EVSDL is already allowed.

Based on these steps, conclusions and possible next steps for ComReg are described in chapter 5.

Sources used in this evaluation are:
- The current copper loop frequency management plan (CLFMP)
- The proposed amendment to the CLFMP
- Eircom trial data provided via ComReg
- Operator inputs provided via ComReg
- Inputs from Rob van den Brink and the DSL expert team at TNO
- Conversations with RTR and BIPT
- Public sources on the situation in other European jurisdictions.

A complete list of sources provided by ComReg can be found in Annex A

1.3 Scope of this evaluation

As requested by Comreg, this is a technical evaluation, analyzing performance in different scenario's and technical aspects of documents provided by ComReg.
Other aspects, other than technical are out of scope of this evaluation.

2 Qualitative analysis

2.1 Schematic representation of EVDSL deployment scenarios

To assess what is the impact on VDSL2 from the cabinet (CVDSL) when EVDSL is introduced in the network, it is necessary to distinguish between the different deployment scenario's.

1. Deployment of EVDSL on direct fed lines: Topology 1 (Figure 2).
2. Deployment of EVDSL on lines passing through a cabinet (Topology 2, Figure 3).
3. Deployment of EVDSL lines on direct fed lines are in a *mixed use cable:* A cable that is used for direct fed lines and for cabinet fed lines: Topology 3 (Figure 4).

The amendment to the CLFMP [1] proposes that EVDSL will be allowed in Topology 1 and topology 3.
In topology 1 cables are exclusively used for direct fed lines and these cables do not pass through a cabinet. Therefore there is no negative impact.
In topology 3, there might be negative impact in case that direct fed lines are in a *mixed use cable:* A cable that is used for both direct fed lines and for cabinet fed lines: Topology 3 (Figure 4). Therefore the TNO evaluation focuses on this deployment scenario.

Fig 2 Topology 1: Direct lines, no negative impact,

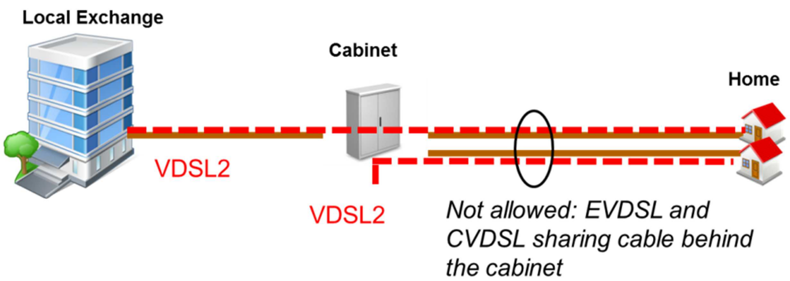

Fig 3 Topology 2: Lines in shared cable and shared route: Negative impact. In the proposed CLFMP this is not allowed

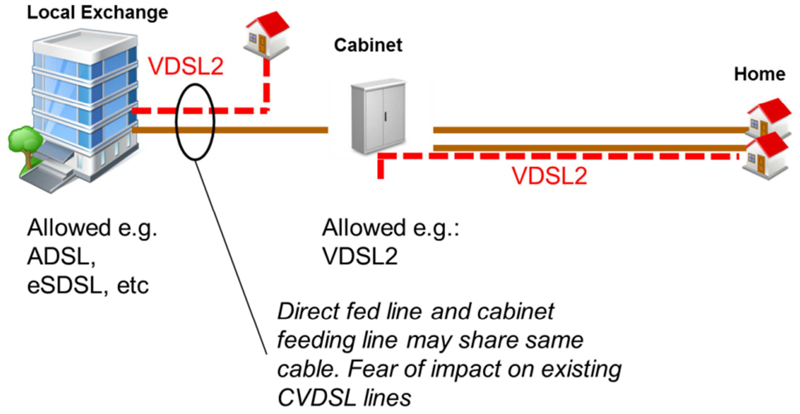

Fig 4 Topology 3: Lines in shared cable but not sharing same route:

2.2 Applying the reference methodology and definition of impact

To be able to assess the impact of EVDSL on CVDSL, it should first be made clear what we mean with the word ‘impact‘.
In this context, we define impact as the difference in potential performance of systems under study between:

- A reference scenario, and
- A modified scenario with new technology introduced in the network

This impact can be positive, zero or negative.

In a fair evaluation, these scenarios should be equivalent, meaning that the number of broadband disturbers in both scenarios is the same.

This approach is called the reference methodology and is described in more detail in [10].

2.3 Scenarios for a qualitative analysis of the impact of EVDSL on CVDSL

For DSL impact analyses, scenarios should take into account cable topology, cable characteristics and the DSL technology mix in the cable.

For this qualitative analysis, we will focus on scenarios that include:

- Cable topology 3 from chapter 1 (figure 4)
- Technology mixes that will be described in the next section:
  - o The technology mix in the reference situation is called the reference mix.
  - o The technology mix in the modified situation, with the new technology introduced, is called the modified mix.

As in this case the scenario’s will only differ in the technology mixes, the impact analysis boils down to comparing performance of system under study (being CVDSL) in the two difference mixes.

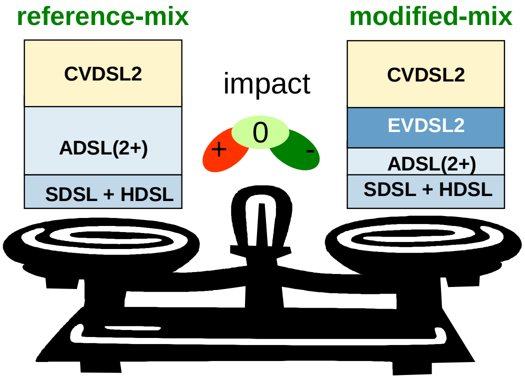

Fig 5: Illustration of the reference methodology

The reference mix should contain:

- A substantial amount of CVDSL.
- A substantial amount of exchange launched “legacy” systems (ADSL, ADSL2+, SDSL etc.)

The modified mix should reflect the questions under study. For this specific evaluation, the central question “Does EVDSL have a negative impact on CVDSL? “ should be split into two evaluation points:

1) What is the impact on CVDSL when replacing ADSL2+ by EVDSL ?
2) What is the impact on CVDSL when replacing ADSL2+ by CVDSL ?

To evaluate these points, a simple reference mix and two modified mixes will be used as displayed in table 1. Pragmatic choices have been made for the number of disturbers. “Legacy systems” are represented only by ADSL2+. Other choices are very well possible, e.g. different numbers of systems, different systems etc. For this analysis, however, these mixes will suffice.

Table 1, Reference mix “Ref” and Modified mixes “Mod1” and “Mod2”

	“Ref”	**“Mod 1”**	**“Mod 2”**
System	Amount	Amount	Amount
ADSL2+	50	0	40
CVDSL	50	50	60
EVDSL	0	50	0
Total	**100**	**100**	**100**

For this evaluation it makes no difference if EVDSL is vectored or not. It does make a difference if CVDSL is vectored or not – this will be explained in the following sections. See also the inset below.

Vectoring

In principle vectoring cancels - or rather: supresses - the crosstalk within the group of CVSDL systems .

Crosstalk from xDSL systems that are not part of the vectoring group, so called “alien disturbers” will not be suppressed and will therefore limit the performance of vectored CVDSL. Typical current alien disturbers in vectored CVDSL are ADSL(2+) systems deployed from the LEX.

2.4 Evaluation of the impact of EVDSL on CVDSL: Downstream

2.4.1 Parameters to determine impact of EVDSL on CVDSL in downstream

In the downstream direction, if there is any negative impact of EVDSL on CVDSL it will be caused by crosstalk via the following mechanism: Signals transmitted by the EVDSL DSLAM that will be received as far-end crosstalk (FEXT) by CVDSL CPE's.

If this crosstalk is relatively high compared to the received CVDSL signal, there may be negative impact.

The crosstalk is the result of what occurs in the different cable sections and their respective lengths as illustrated in Figure 6:

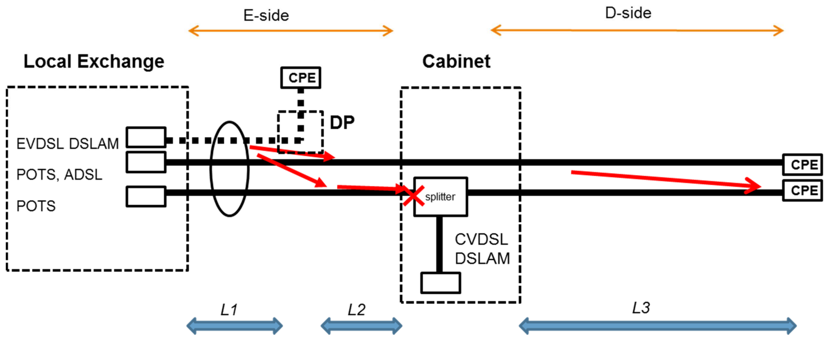

Fig 6 The crosstalk coupling path in topology 3, downstream direction

Coupling ratio downstream/ proportional to length “L1”
EVDSL signals couple into wires in the same cable and act as crosstalk for CVDSL lines. The coupling ratio is determined by the distance Local Exchange (“LEX”) to DP (“L1”).
If EVDSL lines do not share the same binder as CVDSL lines, the coupling ratio will be lower than if they share the same binder.

Crosstalk attenuation/ proportional to Length “L2”
After the DP, the EVDSL crosstalk coupled on other lines will be attenuated corresponding with distance L2 (DP to Cabinet). If distance L2 is “long” the crosstalk will be already very weak before reaching the cabinet.

Splitter
The splitter will block or highly attenuate the DSL signals and crosstalk originating in the LEX on the CVDSL lines. Crosstalk coupling from EVDSL to CVDSL will be via the wire(s) that run from LEX through the cabinet. This coupling is indirect and relatively weak.

Received CVDSL downstream signal level/ proportional to L3
The received signal level is determined by the distance from CAB to CVDSL CPE (“L3”).

Maximum frequency usable by EVDSL / proportional to L1
Another important parameter is the maximum frequency usable by EVDSL. This is mainly determined by the distance Local Exchange (“LEX”) to DP. After a certain

distance, the frequencies used by EVDSL will not exceed the frequency range of ADSL2+. In the latter case EVDSL will never cause any negative impact.
It can also be assumed that when the Cabinet is far enough from the LEX, the crosstalk at frequencies above the ADSL2+ band will be attenuated so much that there will never be any negative impact on CVDSL.

2.4.2 Qualitative Analysis of the impact of EVDSL on downstream CVDSL

For the non-vectored downstream case, the negative impact of replacing ADSL2+ by EVDSL ("Mod1") will be negligible when compared to the negative impact of replacing ADSL2+ by CVDSL ("Mod2").

The reason behind this is that adding an EVDSL line will cause less crosstalk on CVDSL than adding another CVDSL line: The coupling strength is weaker and EVDSL crosstalk has already been attenuated before it arrives at the cabinet. Popularly speaking: non-vectored CVDSL would rather have EVDSL in the cable than other CVDSL.

However, if CVDSL is vectored, crosstalk from other CVDSL lines is cancelled, and adding additional CVDSL lines would cause negligible additional crosstalk. Therefore if EVDSL is deployed in the case of vectored CVDSL, negative impact may be noticeable where it would not be in the case of non-vectored CVDSL.

This negative impact only occurs when EVDSL uses frequencies above the ADSL2+ band (otherwise replacing ADSL2+ in the reference scenario by EVDSL in the modified scenario would not make any difference).
The maximum usable frequency depends on the distance LEX-DP (L1). If this distance is "long" the risk of negative impact is small.

Based on TNO's knowledge of European cable types and previous lab and field experiments, it can be expected that if the distance LEX-DP is larger than approximately 2-3 km, the risk of negative impact is small.

Table 2:
Qualitative estimation of the risk of negative impact of EVDSL on downstream CVDSL in topology 3

L2: DP-CAB / L1: LEX-DP	Short	Long
Short	Risk not negligible	Low risk
Long	Low risk	Low risk

To determine qualitative values for "Short", "Long" and the level of potential impact, a quantitative study including simulations would be necessary.
The negative impact will always be less than when EVDSL would pass through the active cabinet in the same binder as CVDSL.

2.5 Evaluation of the impact of EVDSL on CVDSL: Upstream

2.5.1 Parameters to determine impact of EVDSL on CVDSL in upstream

In the upstream direction, if there is any negative impact of EVDSL on CVDSL, it will be caused by crosstalk via the following mechanism: Signals transmitted by the EVDSL CPE that will be received as near-end crosstalk (NEXT) by the CVDSL DSLAM.

If this crosstalk is relatively high compared to the received upstream CVDSL signal, there may be negative impact.

The crosstalk is the result of what occurs in the different cable sections and their respective lengths as illustrated in Figure 7:

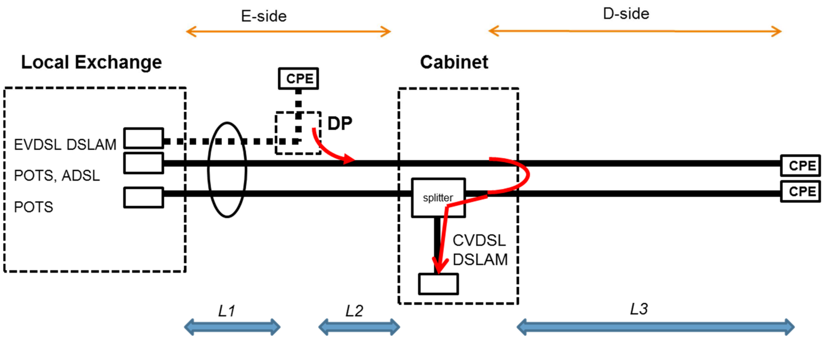

Fig 7 The crosstalk coupling path in topology 3, downstream direction.

Coupling ratio upstream
EVDSL signals couple into wires in the same cable and act as crosstalk for CVDSL lines. As we assume a NEXT-like crosstalk coupling, it roughly is length-independent. If EVDSL lines do not share the same binder as CVDSL lines, the coupling ratio will be lower than if they share the same binder.

Crosstalk attenuation/ proportional to Length “L2”
After the DP, the EVDSL crosstalk coupled on other lines will be attenuated corresponding with distance L2 (DP to Cabinet). If distance L2 is “long” the crosstalk will be already very weak before reaching the cabinet

Splitter
The splitter will block or highly attenuate the DSL signals and crosstalk originating in the LEX on the CVDSL lines. Crosstalk coupling from EVDSL to CVDSL will be via the wire(s) that run from LEX through the cabinet. This coupling is indirect and relatively weak.

Received CVDSL upstream signal level
The received signal level is roughly independent from the distance from CAB to CVDSL CPE (“L3”). This is caused by UPBO (Upstream Power Back-Off). UPBO is a mechanism designed to solve the near-far problem, effectively causing all upstream signals to be the same and relatively low, level, independent of line length [9].
Maximum frequency usable by EVDSL / proportional to L1

Another important parameter is the maximum frequency usable by EVDSL. This is mainly determined by the distance Local Exchange (“LEX”) to DP. After a certain distance, the frequencies used by EVDSL will not exceed the frequency range of ADSL2+. In the latter case EVDSL will never cause any negative impact.
It can also be assumed that when the Cabinet is far enough from the LEX, the crosstalk at frequencies above the ADSL2+ band will be attenuated so much that there will never be any negative impact on CVDSL.

The upstream EVDSL transmit power
Due to the UBPO mechanism [9] the EVDSL upstream transmit power depends on the length L1 (assuming that the customers are located very close to the DP): For short lengths there is low transmit power, for long lengths there is maximum power.

2.5.2 *Qualitative analysis of the impact of EVDSL on upstream CVDSL*

If EVDSL is deployed in the case of CVDSL, there may be negative impact in some cases since the received upstream CVDSL signals are relatively low due to the UPBO mechanism. For short distances L2 (DP-CAB), even with weak crosstalk coupling, the crosstalk level at the DSLAM might be noticeable by the CVDSL receivers, while if the DP is relatively far away from the cabinet, the EVDSL CPEs will transmit at full power. In this case the risk of negative impact is not negligible.
When the distance between DP and Cabinet is large, the upstream crosstalk will be attenuated at some point, not causing any harm to the CVDSL upstream signals.

Table 3:
Qualitative estimation of risk of negative impact of EVDSL on upstream CVDSL in topology 3

L2: DP-CAB / L1: LEX-DP	Short	Long
Short	Low risk	Low risk
Long	Risk not negligible	Low risk

Again, to determine qualitative values for “Short”, “Long” and the level of potential negative impact, a quantitative study including simulations would be necessary.

In the upstream case, the risk of negative impact will already occur in the non-vectored case. For the vectored case, the level of negative impact may be higher than in the non-vectored case if the same UPBO regime is used as currently described in the CLFMP.
If however, new UPBO settings could be designed such that they are tailored for vectoring, allowing the received CVDSL signal levels to be higher. This will reduce the risk of negative impact. An additional benefit is that upstream performance for vectored CVDSL could be improved in general (with or without EVDSL in the cable), depending on loop length distribution. Tailored UPBO for vectoring is not part of the proposed CLFMP.

2.6 Conclusions

The impact on CVDSL is defined as the change in POTENTIAL performance (in a statistical sense) when CVDSL does not operate anymore in a (reference) scenario without EVDSL but has to operate in an equivalent (modified) scenario that includes EVDSL. This impact can be positive, zero or negative, which depends on the details of both scenarios.
A positive impact means that CVDSL performs better in the modified scenario then in the reference scenario. A negative impact means that CVDSL performs worse in the modified scenario then in the reference scenario.

A qualitative analysis has learned that in the case that the distance from the distribution point (DP) to the cabinet is long, it is plausible that the impact is zero or positive. However in case that the distance from the DP to the cabinet is short, it cannot be ruled-out that the impact is negative. It requires a more detailed quantitative analysis to identify how much impact occurs under what condition.

In general, the impact on CVDSL is assumed to be zero or positive when cabinets are “out of VDSL range” from the LEX.

The impact on CVDSL and how often cabinets are “out of VDSL range” can only be quantified when both scenarios are well defined in terms of topology, loop lengths, technology mix, frequency allocations, details on vectoring, and cable characteristics. Quantifying the impact was out-of-scope for the current evaluation.

3 Evaluation of operator inputs

3.1 General remarks

For this evaluation, responses on the ComReg Information Notice 14/72 are available from Eircom, BT, Magnet and ALTO, including (some of) the documents referred to. A full list can be found in Annex A. Documents not mentioned in Annex A were not available for the current evaluation.

For this analysis we will take into account the technical data and arguments found in these responses. Arguments concerning other areas, such as regulatory procedures, commercial considerations etc. are out of scope for this technical evaluation.

3.2 ALTO

ALTO requests that “vectoring is placed on the Skerries cabinet to see the effect of vectoring on the upstream and downstream bitrates of cabinet and exchange side VDSL” as part of an extension of the field trials.

TNO believes that the case of vectoring and non-vectoring are indeed different, and that this aspect should be taken into account. We believe however that it is difficult to get the right insights from a field trial, and that simulations are preferable (see Annex).

3.3 Eircom

Eircom has provided a large amount of technical data and arguments that will be analysed in the following sections. Summarising: The lab and field tests cannot be considered as conclusive, but merely indicative. They indicate that EVDSL will not have a significant impact on CVDSL across the entire network.
In their response to ComReg’s information notice [6], Eircom mentions a desktop study that would prove “no material impact on existing services”. TNO has not seen this study.

3.3.1 Eircom lab tests

Eircom’s lab tests contain results that support the qualitative analysis in chapter 2. Specifically they illustrate:

- The double coupling mechanism *(13 12 06) Proposed Changes to CLFMP Iss 6 (11th Dec Forum)*
- The splitter’s low pass filter *(14 02 05) EVDSL-CVDSL Interference_r2 (update circulated 6th Feb)*
-

However, these lab tests cannot be considered conclusive on the following grounds:

- Principle ground: Not enough statistics: There is large variation in wire pair characteristics in the real network, this is not taken account in lab testing.
- Although the tests illustrate the mechanisms, certain information is lacking such as noise floor measurements.

- Without detailed loop length statistics (L1, L2, L3 in figures 6 and 7) from the Eircom network, the test cases analysed cannot be judged on the level of representativeness.

3.3.2 *Eircom field tests*

Eircom field tests were performed for 3 out of initially 5 selected cabinets:

WST1_005: non vectored
WST1_006: vectored
SKS1_003: non vectored

The timeline of the trial is depicted in figure 8

Fig 8: Timeline of Eircom field trials

There are several aspects that cause the trial results to be indicative only:
- The overall statistics are low . To account for the variations in a live network typically in the order of thousands of lines are required
- The network was not frozen, i.e. many events took place in the trial such as line repairs and adding/ removing xDSL lines both from LEX and CAB.
- As part of the trial, CVDSL lines were reprofiled after the baseline period. This means that if any impact (negative or positive) is to be found, the cause cannot be established unambiguously.

As such, the use of field trials is often an inadequate approach for proving impact.

However, if EVDSL were to have a significant negative impact across all network situations, it would likely be noticeable in the Eircom trial as well.

The trial results as presented by Eircom do not indicate significant changes in actual bitrates or retrain data ((14 07 07) CLFMP July 4th V4 (2)). It would have been good to measure the expected bitrates that the lines would be able to support. A measure of this expected rate is the attainable bitrate reported by the system, although this parameter has its drawbacks:
- The value may change when DSL parameters are changed
- It may depend on the specific hard- and software used.

Again, some indication can be achieved from this value, and TNO has made a quickscan based on the available data, to be found in Annex B. TNO has not seen any significant performance degradation in the data that was analysed.

3.4 BT

BT expresses concerns on the risk of interference. It is correct to state that in general EVDSL and CVDSL will have mutual impact when they share the same cable and when EVDSL lines pass a cabinet where CVDSL is installed. This

corresponds to topology 2 in figure 3 and is a different situation than the one under discussion (topology 3 in figure 4).
We assume BT refers to NICC Report on the technical feasibility of deployment options for VDSL from the exchange [17]. This documents sketches four possible topologies relevant for EVDSL deployment. One topology corresponds to the topology under discussion in the TNO evaluation. However, the analysis done by NICC focuses on another topology, being the worst case topology for mutual interference. Any mutual impact shown in studies assuming this topology cannot be directly translated to the Irish topology under discussion.
Furthermore the negative impact of EVDSL on (vectored) VDSL will be overestimated compared to the impact analysis methodology described in chapter 2. In the NICC document , figure 2 for example, the impact is defined as the performance change due to <u>adding</u> VDSL2 in the exchange (instead of <u>replacing</u> ADSL(2+). In terms of the methodology described in section 2.3, the comparison is made between two <u>non-equivalent</u> scenarios. Adding DSL disturbers will <u>always</u> cause negative impact as the overall crosstalk level in the cable is increased.
Therefore, the outcome may be interpreted as a kind of worst case scenario.

BT has made comments on the test approach. In TNO's words: BT's concluded that the tests are inconclusive since:

- CVDSL lines were given a new profile during the "after period".
- Lines were repaired during the trial.

As already stated above, TNO has similar comments on the test approach.

BT is concerned on the negative impact of EVDSL on vectored CVDSL lines. As discussed in chapter 2, TNO believes that vectored CVDSL lines may be more vulnerable to crosstalk from EVDSL in specific cases.

BT's proposal to allow EVDSL if the nearest cabinet is further than 700m from the exchange is not accompanied by an impact analysis. Such a rule will mitigate the risk of impact in some cases, but for other cases will not help at all. For example, when the Cabinet is at 1000m with a DP close to the cabinet (see chapter 2), we see non-negligible risk of negative impact.

BT provides information on the situation in other countries. The situation in other countries is discussed in chapter 4.

3.5 Magnet

Just like BT, Magnet raises concerns on the trial approach. These are discussed in the previous section.

Magnet provide a reference from Alcatel-Lucent on the situation in other countries [16], which is discussed in chapter 4

4 Examples from other countries in Europe

4.1 Austria

In Austria, the use of VDSL2 from the local exchange is permitted with the following restrictions [11,12]:

The deployment distance is less than 15,7 dB electrical length at 150 kHz (14 dB until the final “switch point “ and 1,7 dB reserve for in-house cabling).

In other words: VDSL2 is allowed to be deployed from the exchange until a certain distance. Beyond that distance, customers are served either with other xDSL (e.g. ADSL) from the local exchange or from cabinet-deployed xDSL. The background of this rule is to prevent mutual interference between EVDSL and CVDSL when they would share the same cable.
The situation currently under discussion in Ireland does not occur in Austria according to our knowledge.

4.2 The Netherlands

In the Netherlands, the use of VDSL2 from the local exchange is permitted in the so-called direct network, and in the so-called indirect network with restrictions.
In the direct network, corresponding to topology 1 in Figure 2, there are no cabinets connected to the cables leaving the local exchanges. This is schematically depicted in figure 9 taken from 13 . In this network, VDSL2 is permitted without restrictions other than spectral masks and power limitations.

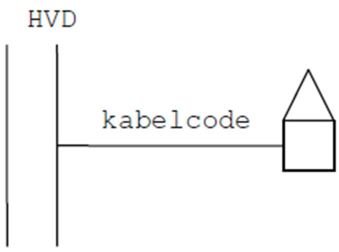

Fig 9, “Direct Net” in KPN’s Access Network.

In the indirect network, VSDL2/Ex will always pass by a cabinet. To prevent mutual unwanted interference [14], VDSL2/Ex is only permitted when the distance between Exchange and cabinet is less than 1.5 km.
TNO has performed studies showing this mutual impact: VDSL2/Ex will have negative impact on VDSL2/Cab in the upstream direction and VDSL2/Cab will have negative impact on VDSL2/Ex in the downstream direction. These studies are company confidential and therefore not public.

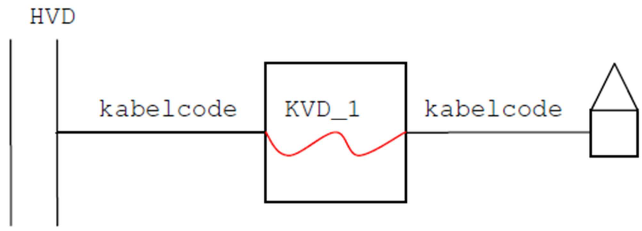

Fig 10, “Indirect Net” in KPN’s Access network.

The situation currently under discussion in Ireland does not occur in the Netherlands according to our knowledge.

4.3 Belgium

In Belgium, according to [15] VDSL2 is permitted from the LEX under the condition that there is either :

- No cabinet in the loop
- A cabinet in the loop “wherefore it has been estimated that over 90% of the end-users behind it are located at less than one km from LEX

Note that in Belgium sometimes an “LDC” is created. This could be considered as a kind of LEX.

In the subloop, VDSL2 is permitted from the LDC:

- When there is no cabinet behind the LDC
- A cabinet in the loop “wherefore it has been estimated that over 90% of the end-users behind it are located at less than one km from the LDC

VDSL2 is permitted in cabinets when consumers cannot be served from LEX or LDC with VDSL2.

In conclusion: End-users sharing the same cable are always served from one injection node to prevent mutual interference.
The situation currently under discussion in Ireland does not occur in Belgium according to our knowledge.

However, in Belgium some cases occur that can be considered exceptional, e.g. ringstructures in the network. For such cases, where there is risk of interference, mitigations have been designed in the form of (additional) spectral limitations.

4.4 Comparison with the Irish situation

In none of the examined jurisdiction, the frequency management plans describe a situation that is similar to the Irish situation in topology 3 as depicted in fig 4.
In the examined countries, the CLFMPs prescribe that VDSL2 from the local exchange and from the cabinet are never used in the same cable AND passing the cabinet
This is also confirmed by the document that Magnet distributed [16] in their response the ComReg Information Notice [5].

5 Conclusion and recommendations

5.1 Conclusions

A request for changing the CLMFP has been made by Eircom to allow EVDSL, with the argumentation that there is no negative impact on CVDSL. Other operators claim that there will be negative impact. The main question in this evaluation was therefore : Does EVDSL have a negative impact on CVDSL?

In topology 1, there is no negative impact, as EVDSL would be deployed in cables that do not pass a cabinet.
In topology 2, there can be negative impact, but the proposed CLFMP excludes the use of EVDSL in this topology.
The discussion is about the proposed CLFMP is topology 3. The main conclusion is: There is non-negligible risk of negative impact for specific cases.
Furthermore:

- The level of impact has not been quantified in this analysis.
- How often these cases occur is cannot be quantified with the current data made available to TNO
- To TNO's knowledge, this topology has not been analysed in other European jurisdictions
- Data has been provided by Eircom indicating that the negative impact is not significant. This data is not conclusive.

Table 4 summary of conclusions

Topology	Negative Impact?	Part of proposed CLFMP amendment
1	No	Yes
2	Yes	No
3	Risk cannot be ignored in some cases	Yes

5.2 Discussion on options forward

The above poses ComReg for the question how to respond to the CLFMP proposal. Basically we see two options, if we assume that the objective is to minimize negative impact:

Option A "Restrict EVDSL"
The first option is to ALLOW EVDSL in topology 1 and to NOT allow EVDSL in topology 3 when cabinets are "too close" to the LEX. This option is based on the facts that:

- The CLMFP proposal does not contain a convincing impact analysis showing (near-)zero impact in topology 3 in all cases.
- After a certain distance LEX-CAB there will not be any negative impact anymore in topology 3.

Option B: “Interim approval” approach

The second option is to ALLOW EVDSL in topology 1 and to conditionally ALLOW EVDSL in topology 3. These conditions should be aimed at minimising and mitigating the risk of negative impact. These conditions are not elaborated further in this analysis, but they.could be along the following lines:

- A method of quantifying any negative impact that will be developed and executed within a certain period
- A set of spectral management mitigation measures will be developed within a certain period

This option is based on the estimation that if any negative impact occurs, it can be quantified and subsequently mitigated with appropriate spectral management rules, such as limiting the EVDSL spectrum or using an optimized UPBO scheme for vectored CVDSL.

5.3 Recommendations

In topology 3, the choice for ComReg is between the two options discussed in the previous section, each with their technical advantages and disadvantages, as shown in table below:

Table 5 Options for ComReg in topology 3

	Advantage	**Disadvantage**
Option A	No negative impact on CVDSL	No gain in bandwidth for households on direct-fed lines in topology 3
Option B	Gain in bandwidths for households on direct-fed lines in topology 3	Risk of negative impact on CVDSL .

Should Comreg choose option A, it is recommended to consider a distance limit from Local Exchange to Cabinet for topology 3. If this distance is above a certain value, than EVDSL could be allowed in those situations.

Should ComReg choose option B, it is recommended that:

- ComReg ensures that the risk of impact will be quantified
- ComReg ensures that proper mitigation strategies are developed

Specifically for option B, TNO suggests that ComReg:

- Formulates guidelines on how to quantify impact and how to mitigate the risk on negative impact.
- Design a process that captures steps and timelines for involved operators.

6 List of references

[1] Eircom CLFMP proposal
[2] Current CLFMP (in force)
[3] BT response to Comreg Information Notice 14/72
[4] ALTO response to Comreg Information Notice 14/72
[5] Magnet response to Comreg Information Notice 14/72
[6] Eircom response to Comreg Information Notice 14/72
[7] Comreg Information Notice 14/72
[8] Insights into crosstalk –understanding the gains of vectoring, Bas van den Heuvel, TNO's DSL seminar 2012
[9] TNO Whitepaper DSL05 The art of Spectral Management; Upstream power back-off for VDSL2
[10] *How to analyze the impact of new xDSL technologies on deployed systems? The specification of the "reference methodology" for local loop studies in the Netherlands*, Rob F.M. van den Brink, TNO report 34373, July 23, 2007 **Not public**
[11] Anschalterichtlinien für den Einsatz von xDSL Systemen im Kupfernetz der A1 Telekom Austria AG ab HV-Standort
[12] RTR Bescheid M 1.1/12 – 106
[13] KPN Wholesale 01-01-2009 - amendement vdsl via het directe net
[14] KPN Wholesale 25-05-2010 - amendement vdsl2 via het indirecte net
[15] Belgacom Raw Copper and Shared Pair Products Annex C Technical Specifications
[16] NICC document High-level analysis for VDSL2 from the exchange, Alcatel-Lucent, 2012-05-01
[17] NICC ND 1517 v1.1.1 (2014-10) Report on the Technical Feasibility of Deployment Options for VDSL from the exchange

7 Annex A Full list of available inputs from ComReg

Title
Comreg Information Notice 14/72
Eircom response to ComReg Information Notice 14/72
Re: ALTO – ComReg Information Notice
Magnet response
BT Response to the ComReg call – Issue 1
NICC ND 1517 v1.1.1 (2014-10) Report on the Technical Feasibility of Deployment Options for VDSL from the exchange
NICC document High-level analysis for VDSL2 from the exchange, Alcatel-Lucent, 2012-05-01
current CLFMP (in force)
(13 11 27)_NGA Forum Update BG v3 (Slides 11-16)
(13 12 06) Draft Copper Loop Frequency Management Plan Issue 7 R1
(13 12 06) Proposed Changes to CLFMP Iss 6 (11th Dec Forum)
(14 02 05) EVDSL-CVDSL Interference_r2 (update circulated 6th Feb)
(14 02 19)_NGA Forum Update v5 (Slides 6-12)
(14 03 05) EVDSL Tests March 5th.pdf
(14 03 19) 140319_NGA Forum Update v3a (slides 4-7)
(14 04 02) NGA Forum Update v8 (slides 1-17)
(14 05 13) EVDSL Trial Test Plan V1.2 2014 05 13
(14 05 13) Response to Initial BT Comments to the eircom Test Plan 2014 05 13
(14 06 06) EVDSL Baseline CLFMP Presentation 20140528
(14 06 16) CLFMP June 18th Issue 1
(14 06 30) changes to CLFMP issue 6 (Slides for 2nd Jul mtg)
(14 07 07) CLFMP July 4th V4 (2)

8 Annex B Eircom field trial sample analysis

8.1 Skerries SKS1_003 Non vectored

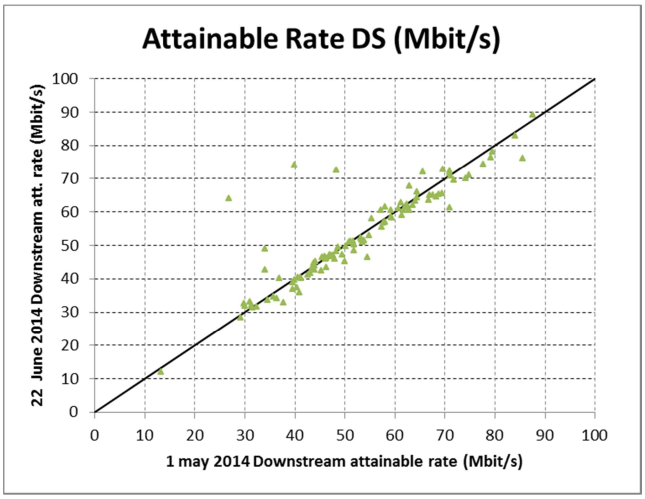

Fig 11 Attainable rates downstream Pre and Post EVDSL activation (1 May 2014 and 22 June 2014 respectively), in cabinet SKS1_003

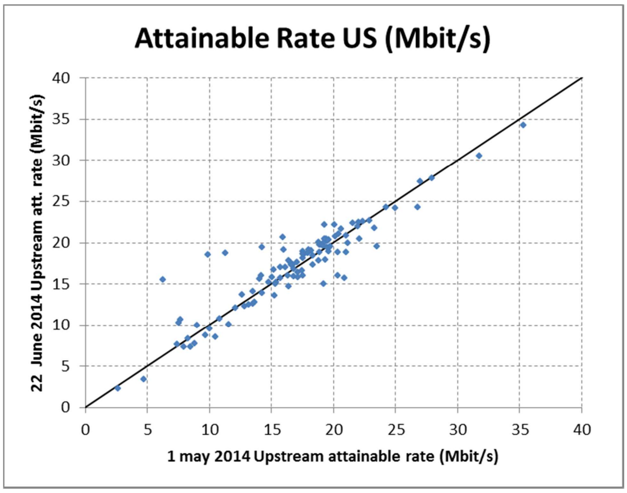

Fig 12 Attainable rates upstream Pre and Post EVDSL activation (1 May 2014 and 22 June 2014 respectively), in cabinet SKS1_003

In the graphs above, two data sets of non-vectored CVDSL datarates are shown (both up- and downstream): The attainable bitrates of CVDSL on 22 June (with EVDSL active) are plotted against the baseline CVDSL attainable bitrates 1 May. The black line signifies “no performance difference” between the two datasets. From these plot, it can be seen that statistically speaking, the performance on these two dates is similar, both for downstream and upstream. This is an indication that EVDSL does not have a significant negative impact on CVDSL, with the remarks mentioned in chapter 3.

8.2 Westport WST1_006 Vectored

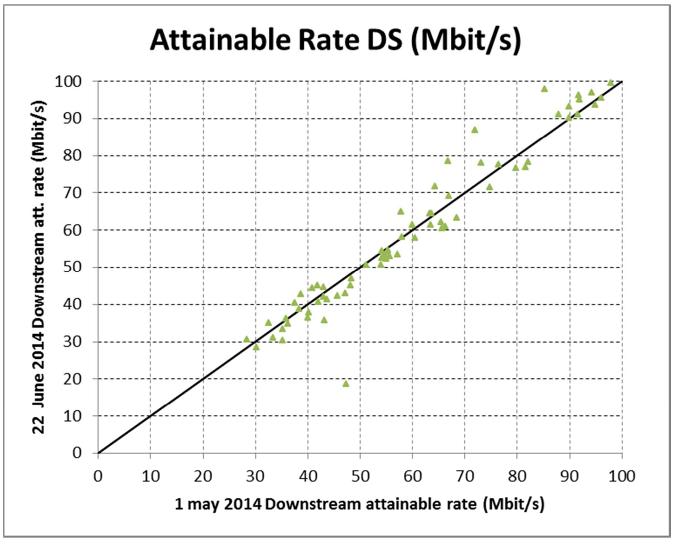

Fig 13 Attainable rates downstream Pre and Post EVDSL activation (1 May 2014 and 22 June 2014 respectively), in cabinet WST1_006

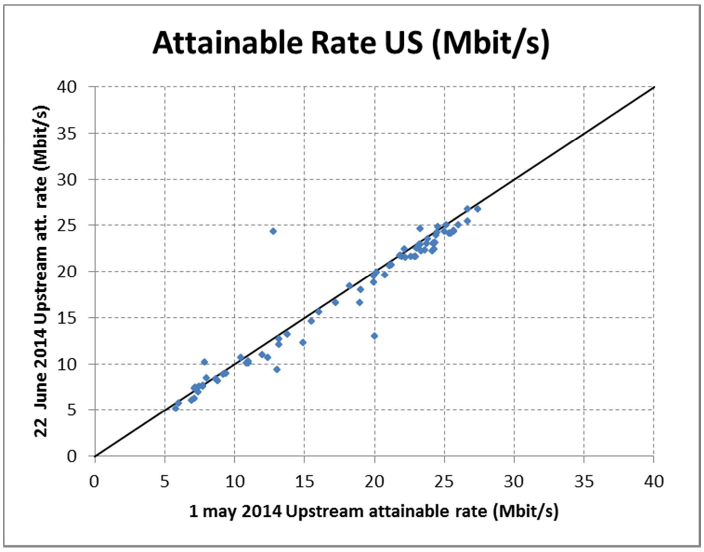

Fig 14 Attainable rates upstream Pre and Post EVDSL activation (1 May 2014 and 22 June 2014 respectively), in cabinet WST1_006

In the graphs above, two data sets of vectored CVDSL datarates are shown (both up- and downstream): The attainable bitrates of CVDSL on 22 June (with EVDSL active) are plotted against the baseline CVDSL attainable bitrates 1 May. The black line signifies “no performance difference” between the two datasets.
From these plot, it can be seen that statistically speaking, the performance on these two dates is similar, both for downstream and upstream. This is an indication that EVDSL does not have a significant negative impact on CVDSL, with the remarks mentioned in chapter 3.

9 Annex C How to perform a qualitative assessment

To verify the quantitative assessment, simulations, lab trials and field trials are possible methods

Each method has its advantages and disadvantages. In TNO's vision, the most suitable method for impact analysis are simulations.

Method	Advantages	Limitations
Simulations	• With simulations, results for many scenario's and variations can be quickly produced. • Simulations results are not limited to a certain hardware/ software version of equipment tested in a lab environment • Simulations rule out any coincidental and statistical effects of a lab setup using real cables • The most suitable approach for impact analyses	• Statistical assumptions on crosstalk coupling make absolute performance prediction for random single copper pairs difficult
Lab testing	• Results reflect current state-of-the art of tested equipment • Results are "real" and can be very persuasive • Results in a lab are repeatable and in a controlled environment.	• Labour intensive • Lab environment usually best case situation compared to real network • Absolute numbers are valid only for certain vendor/ hardware/software combination
Field testing	• Gives information of performance in real world network using current equipment • With enough lines, valuable statistics can be produced	• Labour intensive • Dealing with real customers • Very difficult to introduce variation • Hard to find right test scenario due to practical/ operational limitations • Absolute numbers are valid only for certain vendor/ hardware/software combination