TITLE **Calculation methods for performance evaluations**
proposal for the contents of Spectral Management, part 2

PROJECTS SpM – part 2

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STATUS for Decision

ABSTRACT There is a common feeling within ETSI-TM6 that a spectral management “part 2” is required. Various wish lists have been contributed but it is still unclear what content is required for solving these topics. The lack of detail in TD15 [3] hides the large amount of issues that is to be solved in a single document. We propose to reach this goal in smaller steps, to dedicate “part 2” solely to the *calculation methods* for evaluating performance, and work in parallel (part “3”) on additional issues, as suggested in [3] This gives more progress because unsolved controversial issues will not block the publication of solved calculation method (like happened in ANSI T1E1.4)

1. Why is there a need for a calculation method?

Spectral Management of access networks is of vital importance for bounding the spectral pollution in twisted pair cables, in order to make the most effective use of the available copper resources. Bounding the spectral pollution always means restricting someone’s freedom of deploying systems. Therefore, the biggest challenge of SpM (spectral management) is to find solutions that bring balance between technical feasibility, economic consequences and political objectives.

There is a general feeling within ETSI-TM6 that a "part 2" on Spectral Management is required for supporting SpM decision in various countries. ETSI-TM6, however, is a technical body, not a political or economical body, so ETSI-TM6 can never produce a report that will "rule" what has to be allowed and what has to be forbidden. Therefore, the biggest challenge for ETSI-TM6 is to produce a purely technical document, that stays within these technical limits, while it is still supportive for the ongoing SpM process within Europe.
So what technical content is needed, when ETSI-TM6 opens a work item on “part 2”?

The key question is “spectral compatibility”, which is today an ill-defined quantity. Whatever the right definition will be, **spectral compatibility is scenario dependent** .

- In a network, 100% targeted to the residential market, and in absence of any business market, a scenario might be based on only one flavor of ADSL, for instance “ADSL.FDD over POTS”. So no ISDN, no leased lines, and no other symmetrical services. In such a case, SDSL may be judged by some parties as a *pollutive* technology
- In another network, targeted to both the residential and business market, you will see a mix of ISDN, HDSL (for 2Mb/s leased lines) and different flavors of ADSL. In that case the crosstalk noise is significantly different, and SDSL will appear as a *clean* technology.

So each document that makes judgments upon spectral compatibility has to do that in combination of a well defined (range of) scenario(s), preferably on less then one page of paper.

Next, in order to make fair judgments on spectral compatibility, a commonly accepted *calculation method* is required to demonstrate the impact to deployed services when various Spectral Management “parameters” are changed. An example is to quantify the change in maximum reach or bitrate of deployed systems, when new systems are introduced.

> **Without a commonly *agreed* calculation method, it is impossible to make fair judgments upon spectral compatibility, because parties will disagree about the numbers that are calculated.**

A possible calculation method has been contributed in the past by FSAN [1,2] to a spectral compatibility study dedicated to SDSL. The approach started from a scenario, chosen to be the "reference", and calculated the change in reach for ADSL and HDSL when this "reference" scenario would change into a "modified" scenario. The modified scenario had the same number of broadband systems as the reference scenario, but 50% of the ADSL systems were replaced by SDSL. Although the above mentioned "reference method" was supported by several operators working together in FSAN, the "reference method" has never reached an official status of a "commonly accepted method". Currently, no other method has reached that status as well.

More pioneering work on calculation methods has been done within ANSI-T1E1.4 while preparing the ANSI spectral management standard. Many issues, however, which are important for Europe are not covered by that ANSI document. The lacking issues include:

- Reference models for "HDSL-CAP" modem performance, compliant to ETSI standards
- Reference models for "SDSL" modem performance, compliant to ETSI standards
- Reference models for "ADSL over ISDN" modem performance, compliant to ETSI standards
- Reference models for the Echo-cancelled version of "ADSL over POTS" modems
- Reference models for "VDSL" modem performance, compliant to ETSI standards
- A clear relation between the above reference models and the performance requirements that hold for equipment labeled as "ETSI compliant".
- Calculation models for the *conditions* of a scenario (such as cable loss and crosstalk coupling like being used in the ETSI performance tests). There is no such thing as one cable model for Europe: it must be admitted that all these cable properties are different for various regions/countries. Cable models do exist in ETSI testloops and in an ETSI permanent document [6], so that's a good basis for starting.
- Examples for relevant *configurations* of a scenario (like default technology mixtures), which demonstrate how to specify a full scenario on one page of paper (by referring to a suitable model, collected in an ETSI document). This is the only way to specify (in short) the wide range of different scenarios dedicated to a region/country of interest. ETSI should stay with examples only, and must enable each country/region to define its own scenarios that account for relevant legacy systems and (ETSI) xDSL technologies.

Therefore we propose to solve this within ETSI-TM6 by creating an official report on calculation methods.

In short:

If ETSI-TM6 likes to work on issues like:

- "*Evaluation of spectral compatibility*"
- "*list of compatible xDSL technologies*"
- "*fundamentals of spectral management*"

then ETSI-TM6 needs a commonly agreed ***calculation method***

2. What is proposed?

We propose to open a work item on creating a SpM report "part 2", focused on the following topics:

- To focus on technical methods for calculating the performance (margin, reach, bitrate) of xDSL systems;
- To define several generic models for modems and refer to the ETSI "cable document" for generic cable models; similar to the ANSI approach but now with European cable models.
- To provide parameter values for generic modem models that represent ETSI compliant equipment. These parameters must facilitate a close match to the performance requirements specified in relevant ETSI standards.
- To define/explain the so called "reference method", as the change in performance of a system under test, when the configuration (technology mix) of a chosen "reference" scenario changes into a "modified" scenario, while the conditions (cable characteristics) of both scenarios remain unchanged. This choice of scenario should not be fixed by ETSI, only the *method* should be recommended. Reference scenarios are country dependent.
- To illustrate the reference method by a few examples.

Due to the huge amount of material that is to be incorporated in this document, we propose to restrict the scope to the above issues.

Part 2 shall <u>not</u> draw any conclusion what (change in) performance is acceptable or not!

A first draft for the scope, objectives and table of contents has been attached to this contribution.

Furthermore, we propose to have all issue that are not covered by this proposal to be solved in a (possible) SpM report "part 3".

3. Bibliography

[1] Rob F. M. van den **Brink**, KPN/FSAN: "*FSAN position on the PSD proposal for SDSL (in 983w18)*"; Contribution TD4 (994t04a0.pdf), ETSI-TM6 meeting, Amsterdam, nov 1999.
[2] Rob F. M. van den **Brink**, KPN: "The rationale behind TD4 on Spectral Compatibility of SDSL"; Contribution WD9 (994w09a0.pdf), ETSI-TM6 meeting, Amsterdam, nov 1999
[3] Thomas **Kessler**, T-Nova: "New work item proposal for Spectral Management part 2"; Contribution TD15 (014t15.pdf), ETSI-TM6 meeting, Sophia Antipolis, nov 2001
[4] Rob F. M. van den **Brink**, KPN/FSAN: "Realistic ADSL noise models" Contribution TD37 (994t37a0.pdf), ETSI-TM6 meeting, Amsterdam, nov 1999.
[5] ANSI T1E1.4/2000-002R6 "Spectrum Management for loop transmission systems" draft; revision 6, November 2000 (or a more recent version)
[6] ETSI-TM6(97)02: "Cable reference models for simulating metallic access networks", R.F.M. van den Brink, ETSI-TM6, Permanent document TM6(97)02, revision 3, Luleå, Sweden, June 1998.

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4. Proposed Scope and TOC for SpM Part 2

TITLE: **Reference methods for performance calculations**

1. Scope and objectives

The purpose of Spectral Management of metallic access networks is to bound the spectral pollution originating from all transmission equipment connected to that network, in order to make the most effective use of the available transmission resources.
The art of Spectral Management is to find and define the right limiting rules for achieving this goal.

Bounding spectral pollution means in practice that signal levels may not exceed certain agreed maximum levels, and may additionally mean that the number of signals within a specified signal class may not exceed certain agreed numbers. These limits are intended to be equal for all involved parties that deploy systems over the same access network in a region of interest.
A straight forward approach for selecting these limits does not exist, since it is in general a balance between technical feasibility, economic consequences and political objectives. Moreover, due to the wide variety of cable types and legacy systems deployed in various regions of Europe, these limits may also be region dependent.

The selection of limiting rules is a process that requires an analysis to *quantify* the consequence of deploying systems in one or another way, to form an opinion whether such a scenario is harmful or not. Consequence means in this context the change in performance of transmission systems, such as reach, margin, bitrate, customer penetration, etc.
One way to perform such an analysis is to compare the modified scenario of interest with a chosen "reference" scenario, by calculating the change in performance (decrease or increase) of each system deployed in the reference scenario. This approach is identified here as the *reference method*.

The *objective* of this Spectral Management document is to provide the technical means for calculating the change in performance, compared to a chosen reference scenario. This includes:

- Examples on how to define a *reference configuration* in an unambiguous way, which can be controlled by proper Spectral management rules. They cover the range of technologies that are allowed for deployment, the number of wire pairs that are expected to be occupied by them, and/or the power back-off behavior that is assumed. A reference configuration is region dependent.

- Examples on how to define *reference conditions* in an unambiguous way. They cover intrinsic network characteristics, which cannot be controlled by Spectral Management rules (cable topology, cable loss, cable crosstalk coupling, geographic statistics). A reference configuration is region dependent.
- The definition of *reference properties* of equipment, being compliant to international product standards from ETSI, ITU, ANSI, etc. This means a set of well-defined nominal spectra, transmitted by these modems, and a set of well defined performance models of their receivers.

These objectives enable a consistent presentation of reproducible results, while studying the impact of changing various Spectral Management parameters. Another possible application is a clear methodology for demonstrating spectral compatibility of newly defined equipment with existing equipment.

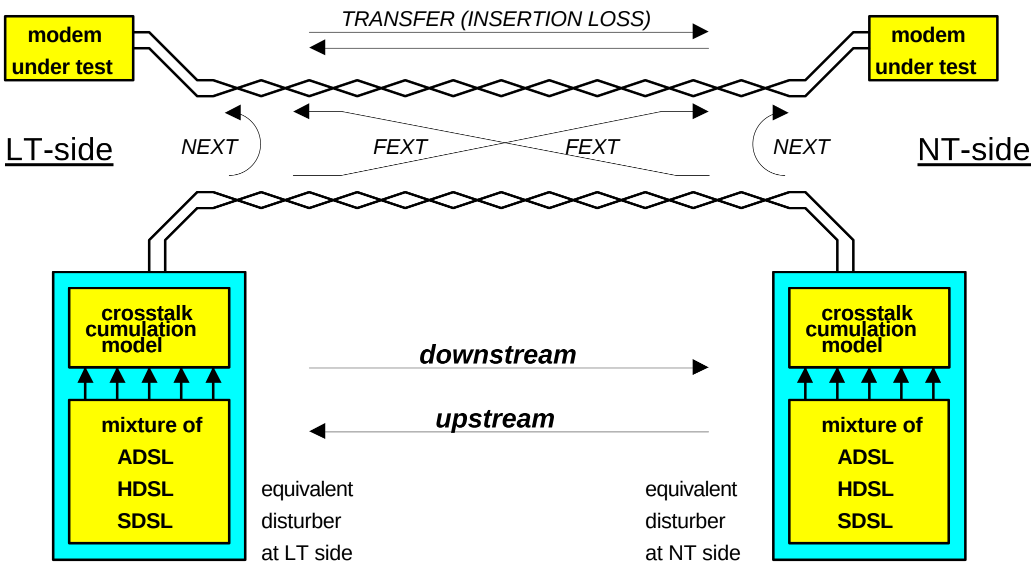
The *scope* of this Spectral Management document is restricted to the methodology for defining reference scenarios and quantifying the change in reference performance. All judgement on what change in reference performance is acceptable or not, is beyond the scope of this document. The same applies for the validity of the example reference scenarios.

2. References

3. Definitions and abbreviations

4. Generic models for cables

4.1. Default cable calculation topology



4.2 Summary of test loop models

<links to various models of testloops for ADSL, SDSL, VDSL>
<additional cable models if required>

4.3 Generic models for crosstalk between wire pairs

4.3.1 Generic models for crosstalk coupling (NEXT, FEXT)

<formulas as used for xDSL testing, but leaving parameter K_{xn} and K_{xf} undefined>

4.3.2 Generic models for crosstalk cumulation (equivalent disturbance)
<FSAN power sum, to evaluate the crosstalk cumulation for co-located disturbers>
<leaving factor K_n is undefined, although ETSI uses K_n=0.6>

4.3.3 Calculating the crosstalk level at the victim modem side
<explaination of the power method to calculate noise into the modem impedance>

4.4 Generic models for noise injection
<indentifying different methods, that account for impedance mismatch or not>
<see the current discussuin within ADSL, and the proposed solution in TD06>
< “forced method”: that ignores all impedance mismatch, as used for SDSL>
< “current injection method”: currently under discussion for ADSL performance calculations>

5. Generic models for xDSL performance

Short Explanation of the difference between noise margin and signal margin. Most of this is similar to the ANSI SpM Report [5]

5.1 technology independent parameters
concept of SNR Gap
echo suppression
receiver noise
5.2. Generic Shannon performance Model
<this is the most simple calculation model, but sometimes adequate>
5.3. Generic multilevel PAM performance Model
<like in ANSI SpM report>
5.4. Generic CAP/QAM performance model
<like in ANSI SpM report>
5.5. Generic DMT performance model
<like in ANSI SpM report>

6. Reference models for xDSL transmitters

< “part 1” defines the worst case upper limits for the PSD, and therefore not suitable for performance calculations. The expected signal is probably a few dB lower. Within FSAN several templates have been developed in the past, close or equal to the nominal value. Only a few of these templates have been published in the past [4].>
<see TD23 of this meeting for these FSAN templates>

6.1 Nominal transmit spectrum for "HDSL.2B1Q"
6.2 Nominal transmit spectrum for "HDSL.CAP"
6.3 Nominal transmit spectrum for "SDSL"
6.4 Nominal transmit spectrum for "ADSL over POTS"
6.5 Nominal transmit spectrum for "ADSL.FDD over POTS"
6.6 Nominal transmit spectrum for "ADSL over ISDN"
6.7 Nominal transmit spectrum for "ADSL.FDD over ISDN
6.8 Nominal transmit spectrum for “VDSL”

7. Reference models for xDSL receivers

This will be the main portion of the document. It provide parameter values of some generic model to evaluate the margin of some technology. The model is to be validated by showing how close it can predict the ETSI performance requirements specified in the associated xDSL standard
For instance SDSL: Gap=6.6 dB, Echo=-50dB, Noise=-110 dBm, BitDensity=3 bits/symbol, Overhead= …, etc.
<see TD23 of this meeting>

7.1 Reference performance model of"HDSL.2B1Q"
7.2 Reference performance model of"HDSL.CAP"
7.3 Reference performance model of"SDSL"
7.4 Reference performance model of"ADSL over POTS"
7.5 Reference performance model of"ADSL.FDD over POTS"
7.6 Reference performance model of"ADSL over ISDN"
7.7 Reference performance model of"ADSL.FDD over ISDN
7.8 Reference performance model of“VDSL”

8. Examples of defining a reference scenario

This section should demonstrate how to define a full scenario in less that one page of paper, be referring as much as possible to the described reference models
These scenario’s are examples only, and enable for each scenario to calculate the performance of each involved system. If, for a specific purpose, one of these scenarios is labeled as “reference” and another one as “modified” then the change in performance is a nice demonstration of what the consequences are of changing for instance the technology mix. This can be a basis in what context (= specific scenario) the word “spectral compatibility” has got a meaning.

8.1 Example scenario A

8.1.1 Assumed configuration

Number of wire pairs	*Technology mix (this example is FSAN noise model B for ADSL)*	*Target noise margin*
10	ISDN.2B1Q	-
2×2	HDSL.2B1Q (2-pair)	6 dB
15	ADSL over ISDN (E.C.)	6 dB
15	SDSL (2.3 Mb/s)	6 dB

8.1.2 Assumed conditions

property	**Model name**	**Parameter values**
Cable model	ETSI testloop “X”	-
Crosstalk cumulation	ETSI default model	K_n=0.6
Crosstalk coupling	ETSI default model	K_{xn}=–50 dB @ 1 MHz K_{xn}=–45 dB @ 1 MHz, 1 km
Noise injection	Current injection	Z_{line}= 135 ohm Rv=135 (HDSL/SDSL/VDSL) Rv=100 (ADSL)

8.1.3 Evaluated performance for this scenario

Margin of technology “HDSL.2B1Q” as a function of cable length
Margin (or bitrate) of technology “ADSL over ISDN” as a function of cable length
Margin (or bitrate) of technology “SDSL” as a function of cable length

8.2 Example scenario B

8.3 Example scenario C

8.4 Example scenario D