TITLE **Receiver performance model for "ADSL over ISDN" (EC)**

PROJECTS Spectral Management, part 2.

SOURCE: KPN

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STATUS for Decision

ABSTRACT Part 2 of the SpM requires a range of calculation blocks, including receiver performance models for "ADSL over ISDN" (EC). These calculation models are obtained by reverse engineering of the ADSL performance requirements using the performance test prescriptions and simulation assumptions. The predicting performance of the extracted calculation models is in line with the performance requirements prescribed in the ETSI ADSL standard.

1. Rationale behind this proposal

Part 2 of the Spectral management report requires the description of performance models consisting of a range of individual calculation blocks. All these blocks together build up a generic performance model that evaluates the effective SNR (signal to noise ratio) of the received signal, as intermediate result, followed by a line-code specific detection block resulting in a predicted performance.

A generic performance model can be made specific by defining all involved parameter values. When that model predicts a well-defined (reference) performance under well-defined (reference) stress conditions, the specific model is identified as a reference performance model.
This contribution proposes performance parameter values for "ADSL over ISDN" (EC, with spectral overlap) resulting in a calculation model that is capable for predicting the performance of an ETSI compliant "ADSL over ISDN" modem under ETSI (reference) stress conditions. Extracting the performance parameters is straightforward because it is "the other way around" of defining the performance objectives. The extracted parameters are in line with the simulation assumptions given in [3] used for creating the performance requirements.

2. Receiver performance model

The reference performance model is based on a generic performance model, for which the parameter values are specified. Some of these parameter values are clearly specified by the ADSL standard [2] or are prescribed in [3] where common simulation assumptions are given which are used to generate the performance numbers. Other values are extracted by fitting the predicted performance with the required performance.

The simulations are in accordance with the performance test prescriptions as specified in the standard (e.g. the simulations assume a noise injection based on the calibration prescriptions using complex impedances).

Two mathematical models have been fitted for predicting the reference performance of the "ADSL over ISDN" modems, one for the downstream and one for upstream direction. The calculation models are based on a first order input model cascaded by the generic DMT model. The model for the input block evaluating the effective SNR is called "first order" because it models all input imperfections by

one parameter: the Internal receiver noise (P_{RN0}). All the remaining imperfections are incorporated in the effective SNR-Gap (Γ) of the DMT detection model as implementation losses. Figure 1 depicts the flow diagram of the calculation model.

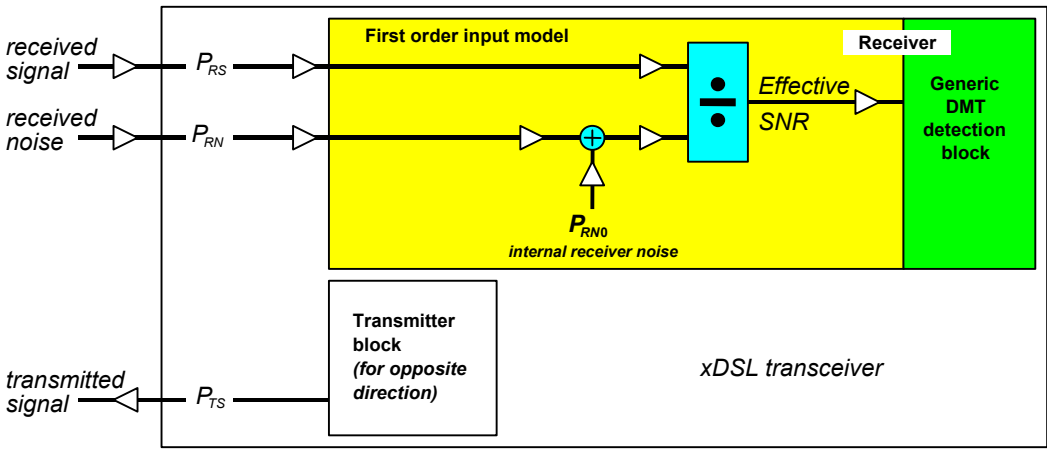

Figure 1: Flow diagram of a transceiver model based on a first order (linear) input model.

To enable signalling, error correction and synchronisation, the actual line rate on the copper wires of ADSL is higher than the data rate (payload bitrate). According to [3] a 13% Reed Solomon overhead and 32kbps framing overhead is assumed. For (low) data rates with S=16, R=16 has been assumed instead of 13% coding overhead. The proposed reference model for ADSL accounts for this overhead as:

$$linerate = \max((datarate + 8 \times symbolrate) \times 1.13, datarate + 16 \times symbolrate) \text{ [b/s]}$$

According to [3], a raw coding gain of 4.25 dB is assumed.

2. Literal text proposal

The text below proposes literal text for inclusion in clause 6 of the Spectral Management draft, part 2.

6.6 Receiver performance model for “ADSL over ISDN” (EC)

This calculation model is capable for predicting the performance of an ETSI compliant “ADSL over ISDN” modem. The reach predictions of this model are close to the ETSI reach requirements under the ETSI stress conditions as specified in the ETSI ADSL specification [2]. Deviations between the predictions and requirements are less then 80m. The validity of the predicted performance holds for a wider range of stress conditions.

6.6.1 Building blocks of the receiver performance model

The receiver performance model for ETSI compliant “ADSL over ISDN” is build-up from the following building blocks:

- A first order (linear) input model for the input block (without echo and equalization imperfections), specified in clause 5.1.1.
- The generic DMT detection model, specified in clause 5.2.4.
- The parameter values specified in Table 1 of the succeeding clause.

6.6.2 Parameters of the receiver performance model

The parameter values, used in the receiver performance model for ETSI compliant “ADSL over ISDN” modems, are summarized in Table 1. Part of them is directly based on ADSL specifications. The remaining values are based on theory.

Model parameter		***DMT model***		
		Upstream	***Downstream***	***Remarks***
SNR-Gap (effective)	Γ_{dB}	7.8 dB	7.5 dB	
SNR-Gap in parts	Γ_{DMT_dB} $\Delta\Gamma_{coding\_dB}$ $\Delta\Gamma_{impl\_dB}$	9.75 dB 4.25 dB 2.3 dB	9.75 dB 4.25 dB 2.0 dB	
Receiver noise	P_{RN0_dB}	–135 dBm	–135 dBm	
Symbol rate	f_s	4000 baud	4000 baud	
Data rate	f_d	64 … 640 kb/s	64 … 6144 kb/s	
Line rate	f_b	$f_{bl} = f_d + 16 \cdot f_s$ $f_{bh} = (f_d + 8 \cdot f_s) \cdot 1.13$ $f_b = \max(f_{bl}, f_{bh})$	$f_{bl} = f_d + 16 \cdot f_s$ $f_{bh} = (f_d + 8 \cdot f_s) \cdot 1.13$ $f_b = \max(f_{bl}, f_{bh})$	
Bits per symbol	b	f_b/b	f_b/b	
Available set of tones	*tones*	[33:63] $= [k_1 : k_2]$	[33:95 , 97:255] $= [k_1 : k_2 , k_3 : k_4]$ Tone 96 = pilot tone	*DMT tone k = 64 does not convey any bits because it is reserved as pilot tone.*
Carrier frequency of tone 1	f_c	4.3125 kHz	4.3125 kHz	
Bit-loading algorithm		Fractional	Fractional	*See TD9 [4] (clause 5.2.4)*
Minimum bit-loading	Δb_{min}	2	2	*Bits per carrier*
Maximum bit-loading	Δb_{max}	15	15	*Bits per carrier*

Table 1: Values for the performance parameters extracted from the ETSI performance requirements under ESTI stress conditions.

End of literal text proposal

3. Validation of the reference model

In this section the validity of the reference model for ETSI compliant “ADSL over ISDN” is graphically demonstrated by plotting the ETSI performances requirements and the performance predicted by the reference models in one figure.

The figures below illustrate how close the reference performance model for “ADSL over ISDN” can predict the performance requirements from the ADSL standard. Figure 2 through Figure 8 are dedicated to the upstream “ADSL over ISDN” receiver while Figure 9 through Figure 15 are dedicated to the downstream receiver. These figures depict for test loop #2 to loop #7 the predicted reach-bitrate curves under four noise models.
Each plot shows two curves, one for the predicted reach-bitrate and another for the ETSI reach requirements. The green curve with the “×” markers indicate the required reach according to the ETSI standard, while the red curves indicate the predicted reach according to the extracted ADSL performance model. Note that the upstream reach requirements belonging to noise model FB and FC entirely or partly overlap. Furthermore note that the ETSI upstream reach requirements for the lowest bitrates in case of noise model FA, FB and FC are limited by the longest reach in the downstream direction.

Analysing the complete set of figures, it can be concluded that the performance prediction of “ADSL over ISDN” over the full range is very close to the ETSI requirements. The maximum deviation between the predicted performance and the ETSI requirements is less than **80m**.

“ADSL over ISDN” upstream

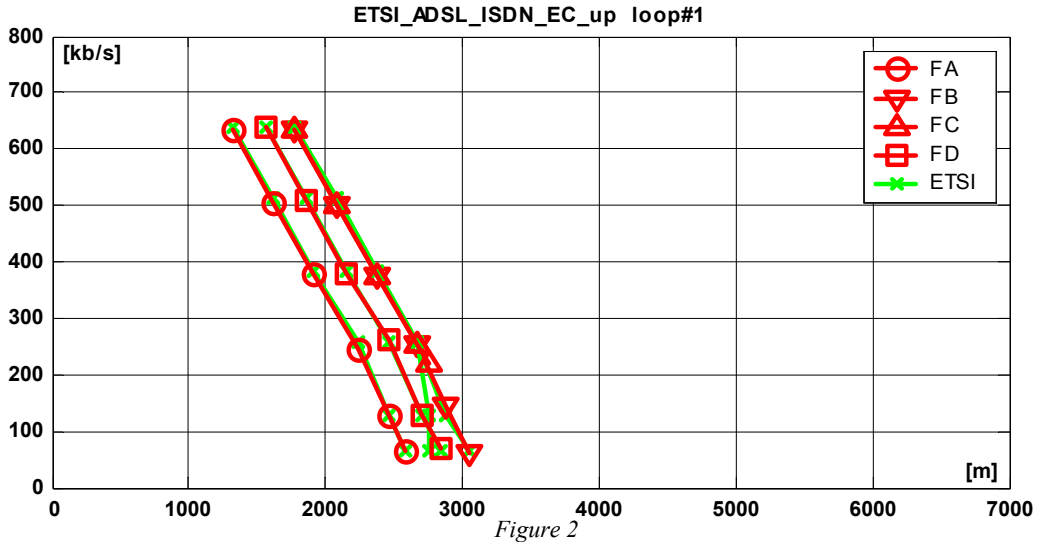

Figure 2

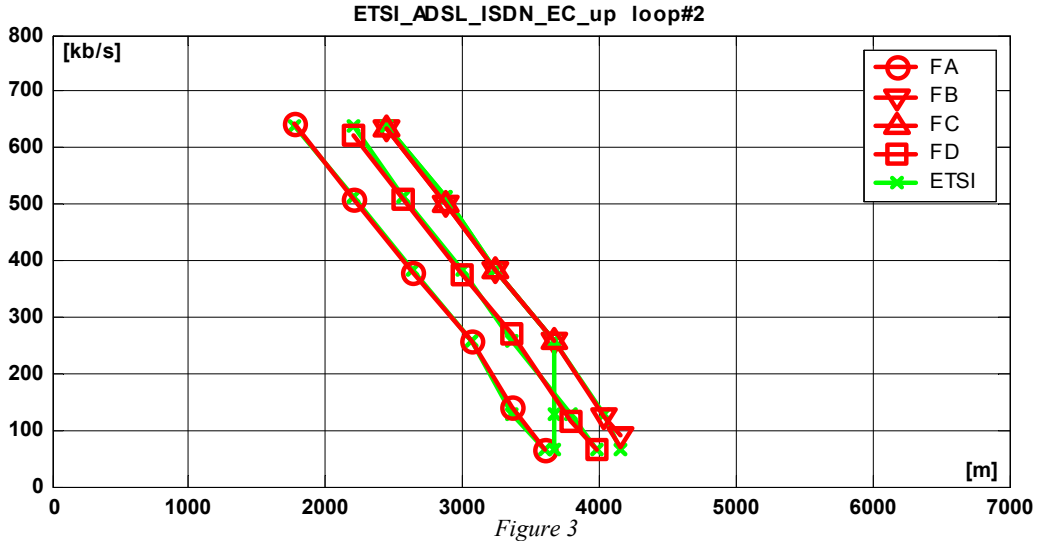

Figure 3

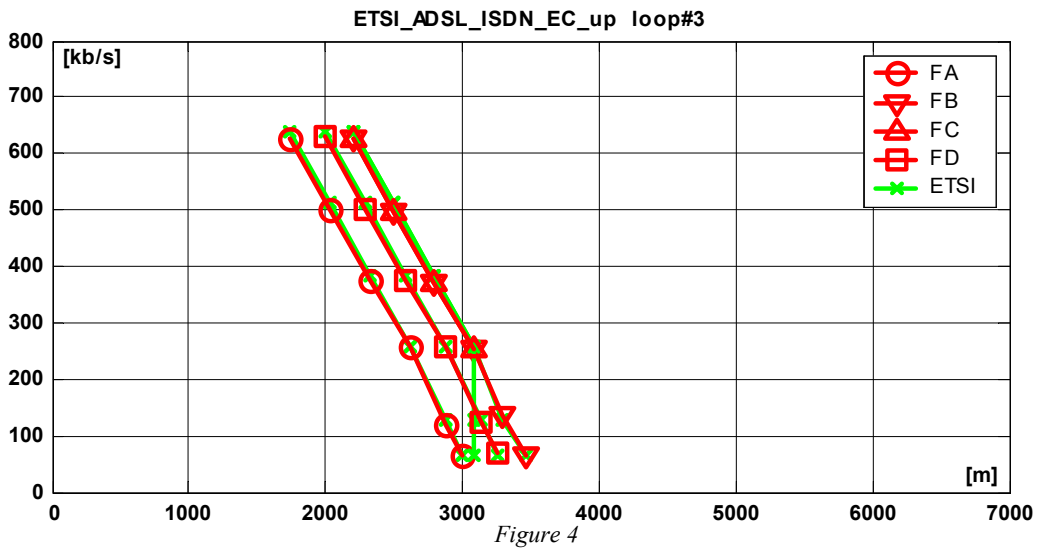

Figure 4

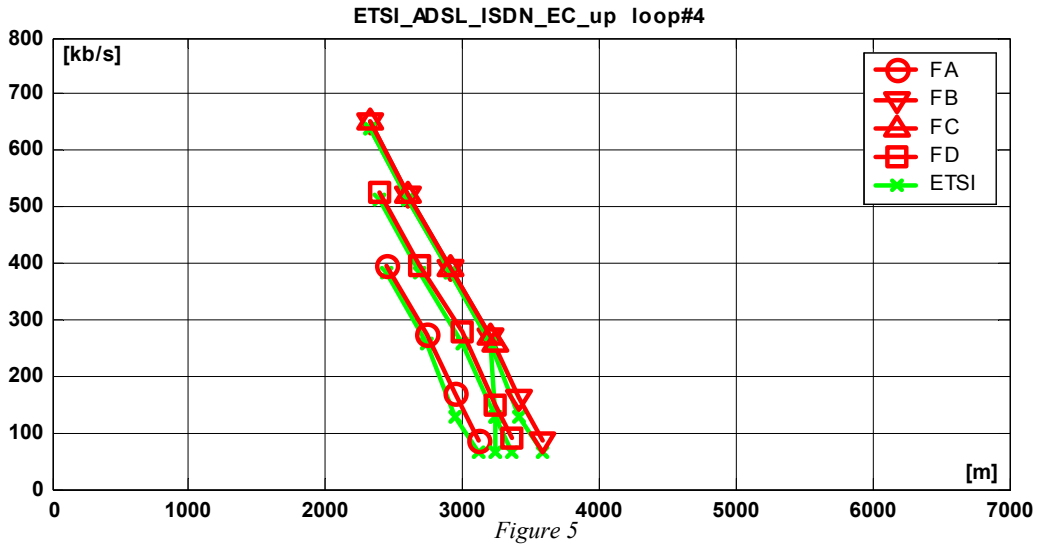

Figure 5

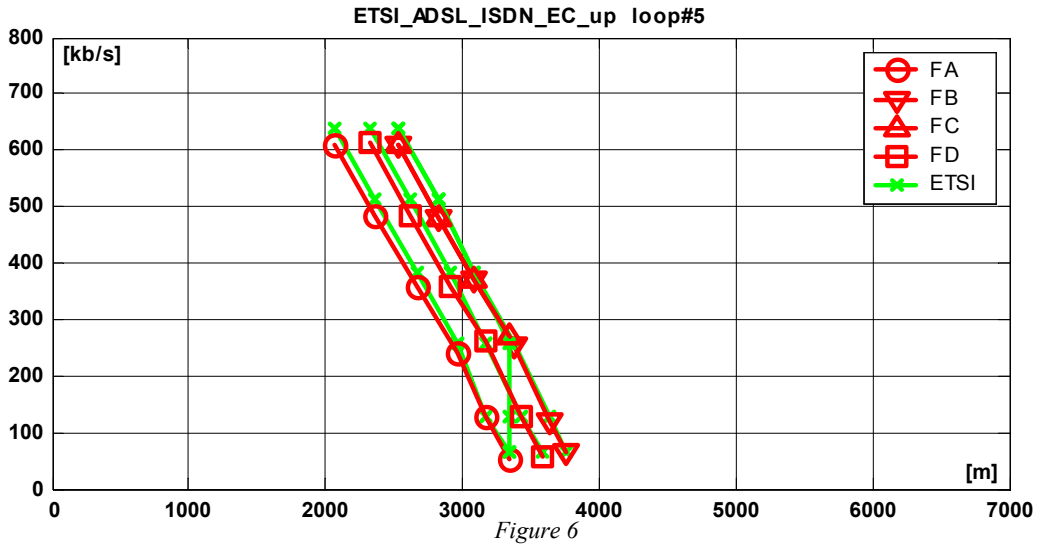

Figure 6

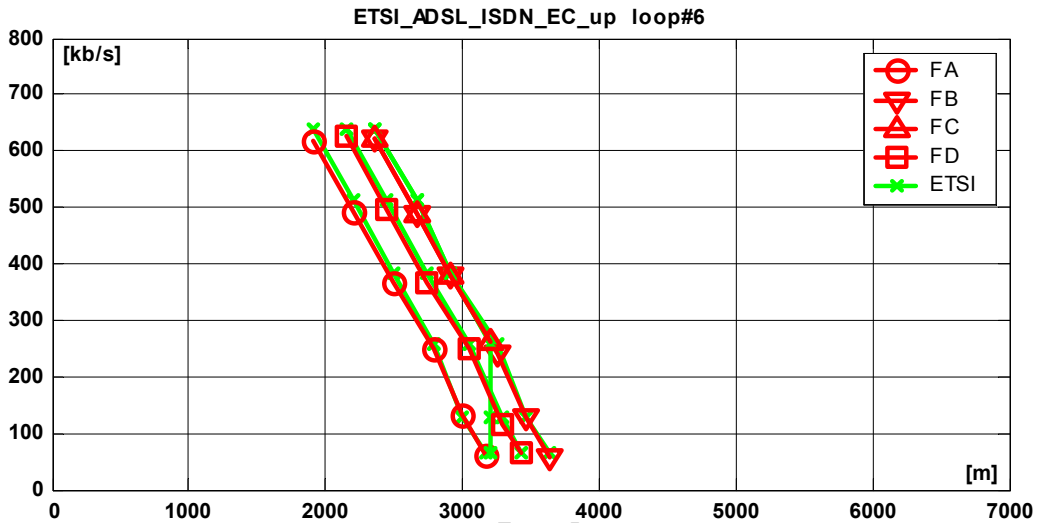

Figure 7

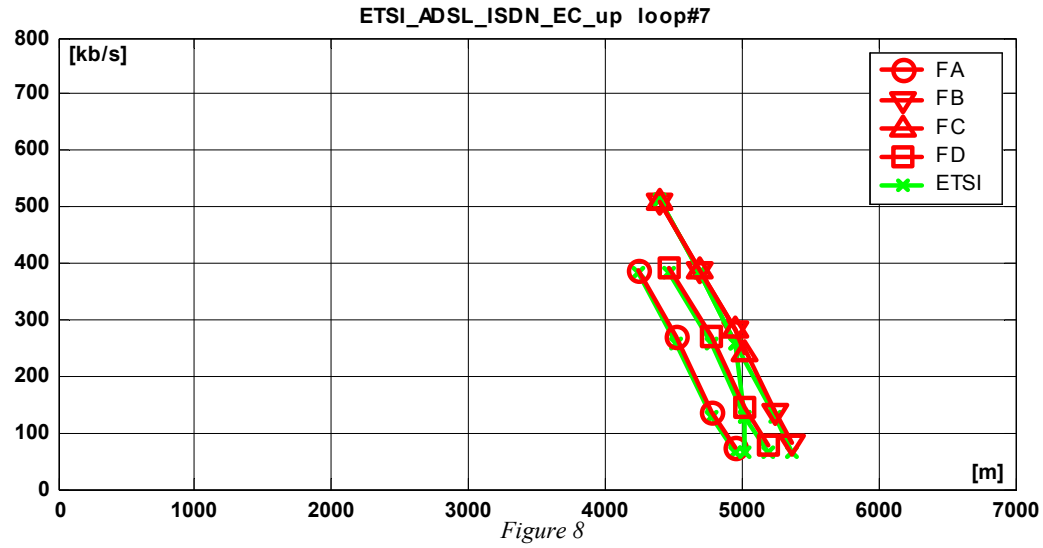

Figure 8

"ADSL over ISDN" downstream

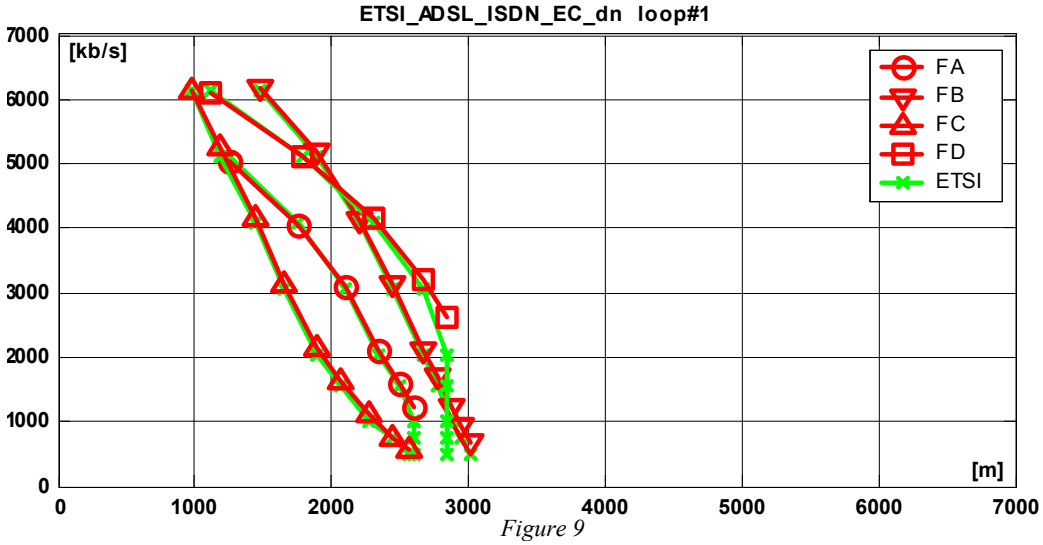

Figure 9

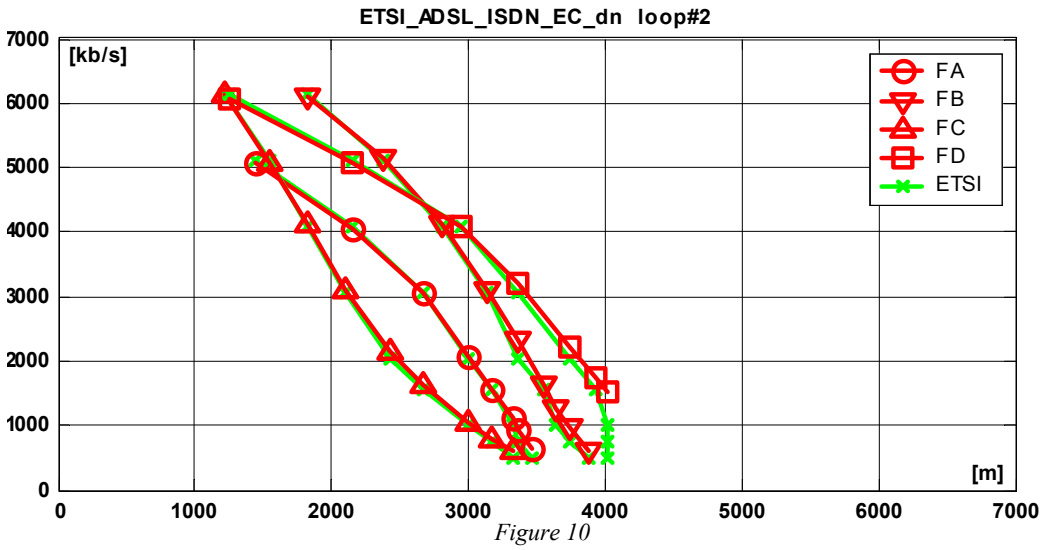

Figure 10

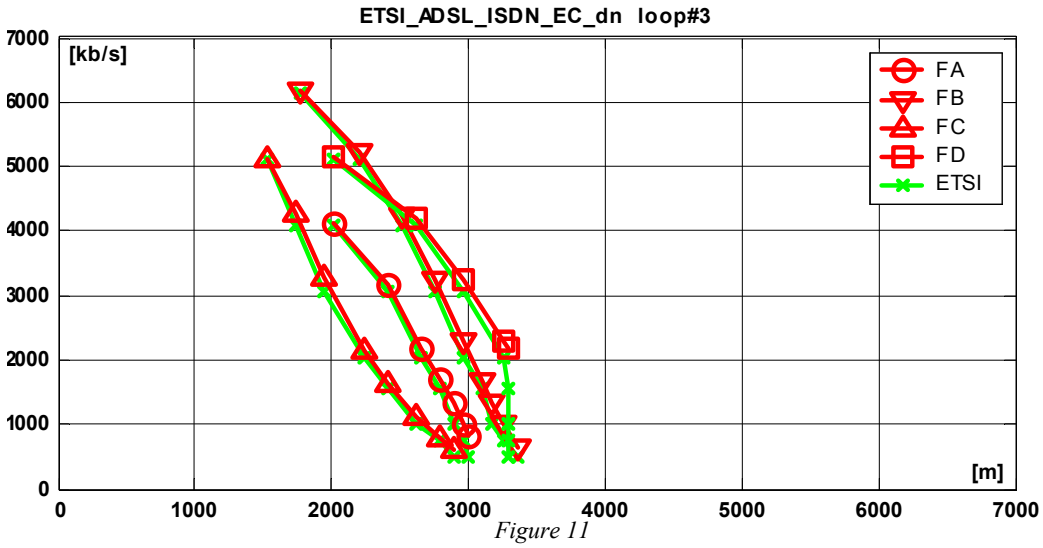

Figure 11

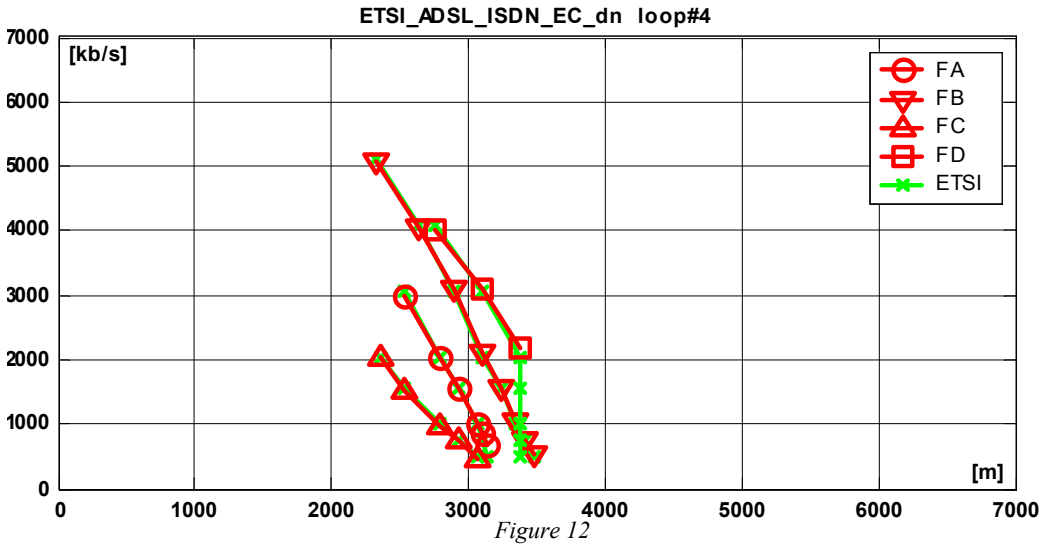

Figure 12

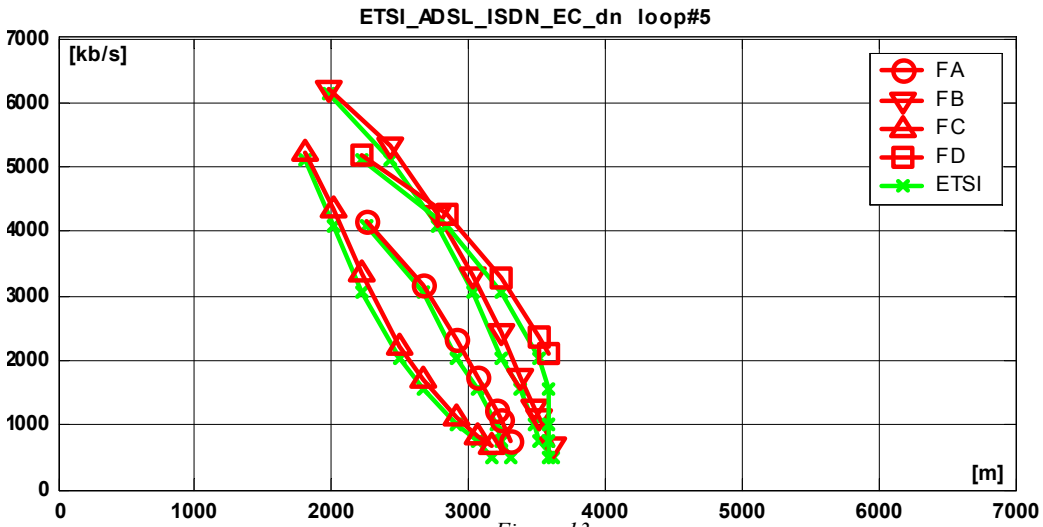

Figure 13

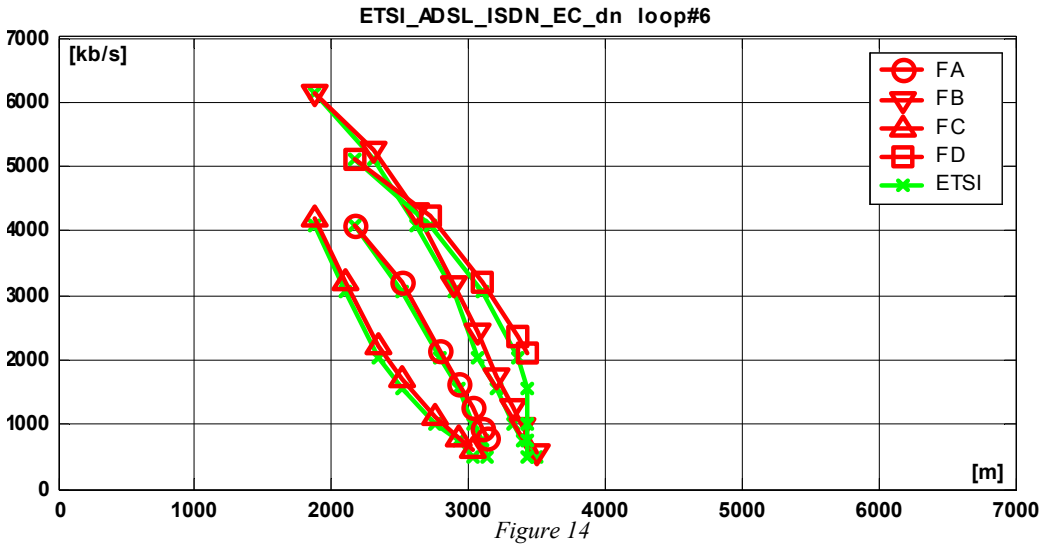

Figure 14

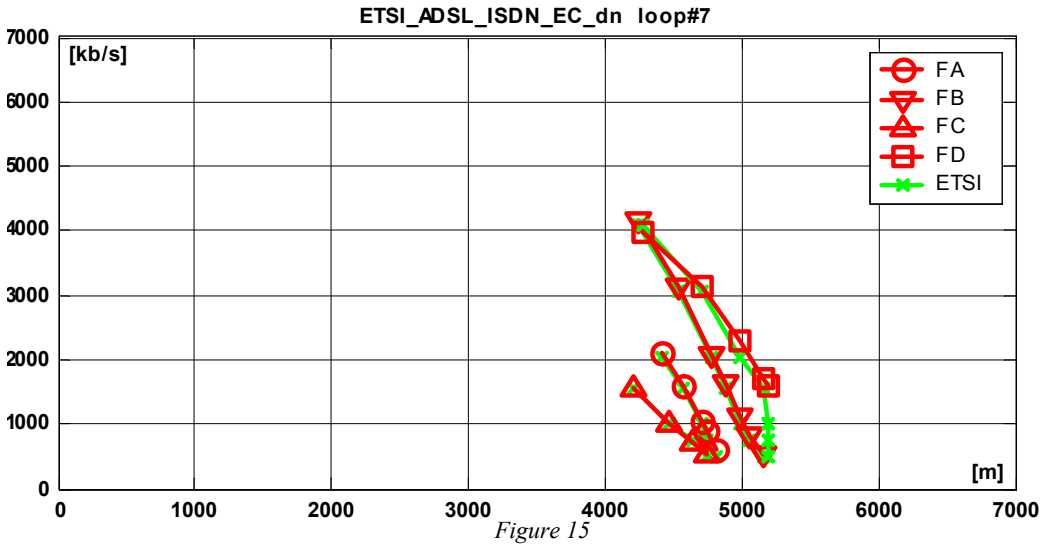

Figure 15

5. References

[1] ETSI WG TM6, permanent document TM6(01)21: ETSI document M01p21r3, “, Living List for SpM part 2”, Oct 25, 2002.

[2] ETSI-TS 101 388 v1.3.1 (2002-05): “*Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Asymmetrical Digital Subscriber Line (ADSL)-European specific requirements*”, *ETSI, May 2002.*

[3] T. Nordström, ETSI TM6/WD 20 (021wd20*): “Proposal for ADSL Performance Requirements”, ETSI, Torino, Italy, February 4-8, 2002*.

[4] ETSI TM6/TD09 (032t09): *“Generic DMT detection model”, ETSI, Reykjavik, Iceland, June 23-27, 2003.*