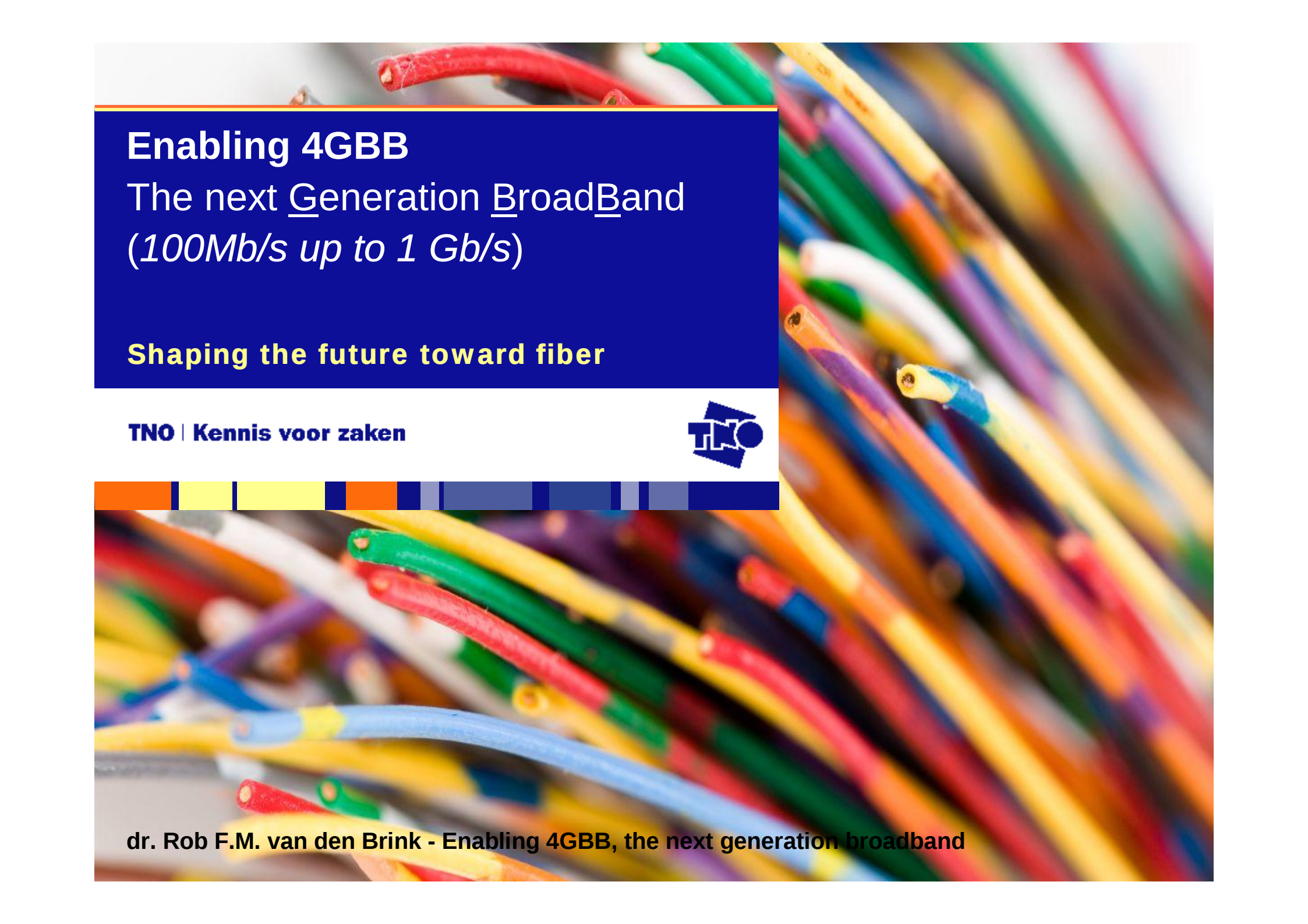




Enabling 4GBB

The next Generation BroadBand
(100Mb/s up to 1 Gb/s)

Shaping the future toward fiber

TNO | Kennis voor zaken



dr. Rob F.M. van den Brink - Enabling 4GBB, the next generation broadband

1. How to enable broadband? (for Telco's)

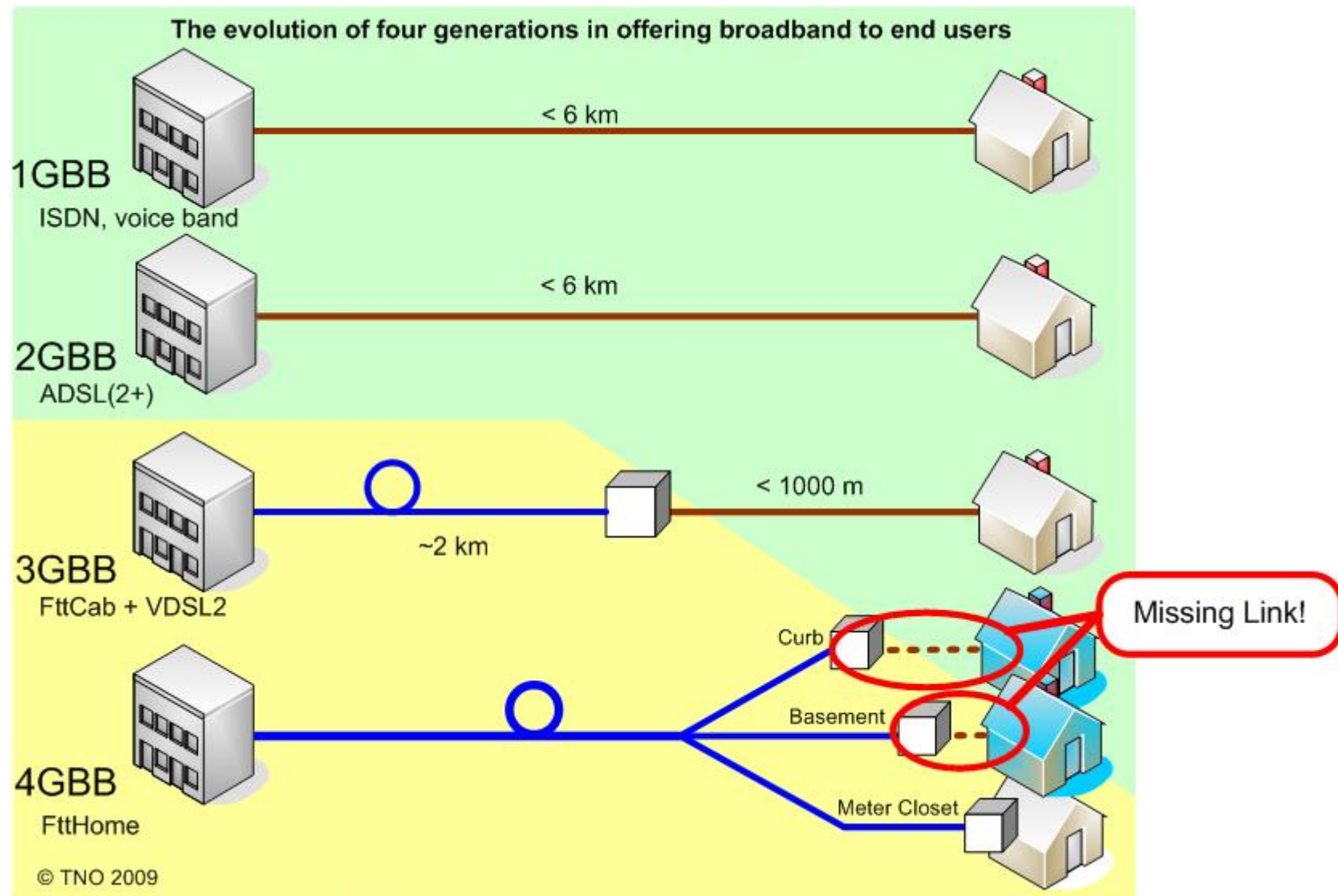
By visionairs à Disruptive

- Fiber to the Home
 - 100 – 1000 Mb/s is needed anywhere
 - predicted during the last 25 years

In practice à Gradual grow + different options

- Narrow band (<33kb/s):
 - voice band modems
- 1GBB (33k-1Mb/s):
 - ISDN (NL:1988?)
 - first ADSL subscriptions (NL:1998)
 - first cable modems
- 2GBB (1-10 Mb/s), Commodity in NL (2009 ≈80% home connections)
 - ADSL2/ADSL2p, HDSL (1995), SDSL(2000) NL: (2010 ≈ 50%)
 - Cable modems (DOCSIS 2.0) NL: (2009 ≈ 30%)
 - *some fiber to the home (<3%)*
- 3GBB (10-100MB/s)
 - VDSL1(1998/2001), VDSL2(2006) *fiber to the cabinet*
 - Cable modems (DOCSIS 3.0)
 - *more fiber to the home (subscribed, not passed-only or connected-only)*
- 4GBB (100M-1Gb/s):
 - *many cable links ("cable operators")*
 - *many FttH links ("Telcos")* **B** this presentation

1. How to enable broadband? (for Telco's)



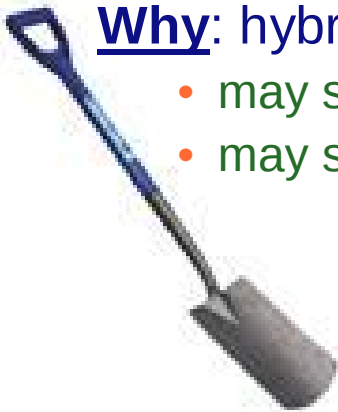
2. Hybrid FttH - complementary to full FttH

FttH is not only fiber beyond the front door

(hybrid fiber/copper is also possible)

Why: hybrid has possible techno-economic advantages

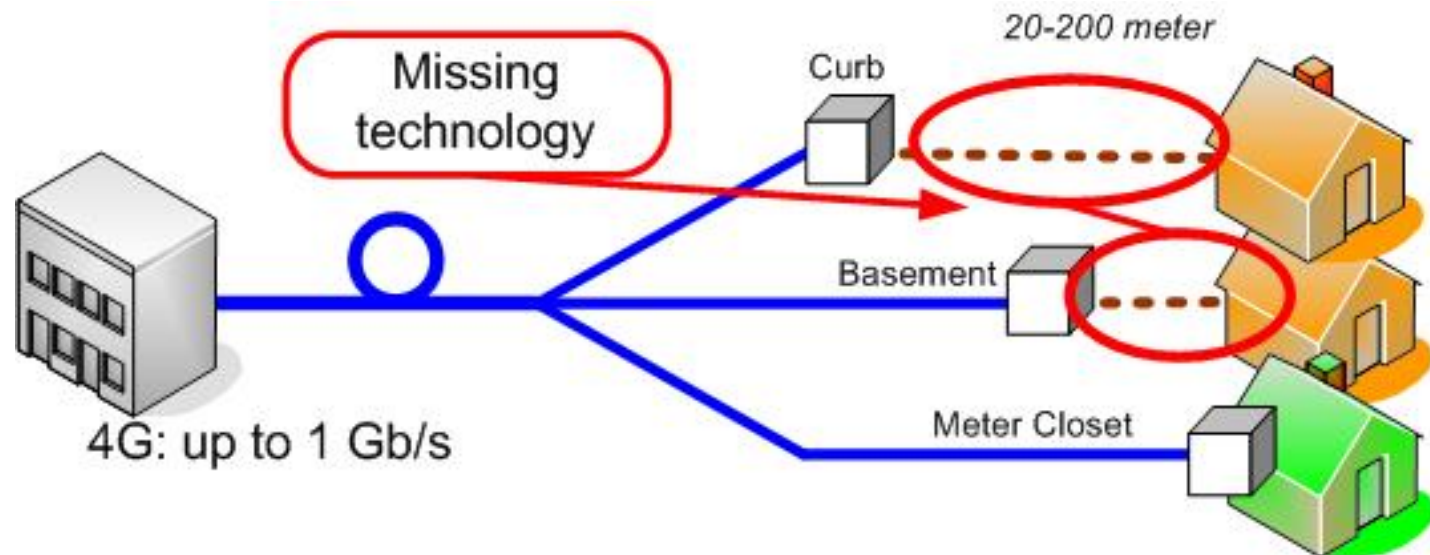
- may save costs for digging/installation when copper can be reused
- may save installation time, so faster roll-out



Where: possible scenarios

- apartment buildings, multi-tenant houses, city centers
- FttH: 80% beyond the front door? – full fiber
- FttH: 20% up to the basement or curb (footway boxes)? – hybrid fiber
- 20% covers a lot of connections!

2. Hybrid FttH - complementary to full FttH



- **How:** hybrid = reusing existing wiring (only when attractive)
 - bridging the last 20-200m
 - via bonded quad: 2 telephony wire pairs simultaneously, when possible
 - up to 1 Gb/s, using a new (ultimate) DSL technology
- **How:** hybrid = distribution points:
 - fiber to multiple copper, and reverse
 - Footway boxes, basement boxes, house front boxes, ...
 - Power feeding from meter closets

2. Hybrid FttH - is up to 1 Gb/s feasible via copper?

- Today: 1 Gb/s Ethernet via copper (1000 BASE-T)
 - availability
 - consumer product, “standard” in many PC’s
 - copper medium
 - 4 twisted wire pairs (“250Mb/s per wire pair”)
 - bonded transmission via 4 pairs
 - CAT 5 quality (well twisted, less crosstalk)
- Today: 10 Gb/s Ethernet via copper exists as well
- In progress: G.hn (home networking transceivers) up to 1 Gb/s

Transceivers of 1Gb/s Ethernet

- similar to SDSL (PAM5, 4 levels, 2bits/symbol)
- 250 Mb/s per wirepair, about 80 MHz, first dip at 125 MHz
- echo cancellation, crosstalk cancellation (against NEXT)
- up to 100m, (according to the standard)

CAT-5 CABLE



2. Hybrid FttH - is up to 1 Gb/s feasible via telephony wiring?

Many questions to be solved

Is it technically feasible via multi-wire telephony cabling?

- Cable measurements up to 500MHz
- Noise measurements (impulses, RFI) in operational networks
- modeling, simulation, bitrate predictions
- new transmission technologies (bitrate, MIMO, remotely powered, ..)

• Is it economically attractive?

- Geographic statistics of network topologies
- when using “hybrid fiber/copper”, when “full fiber”

• Will it be available in time?

- should initiate a standard
- communication toward standardization bodies

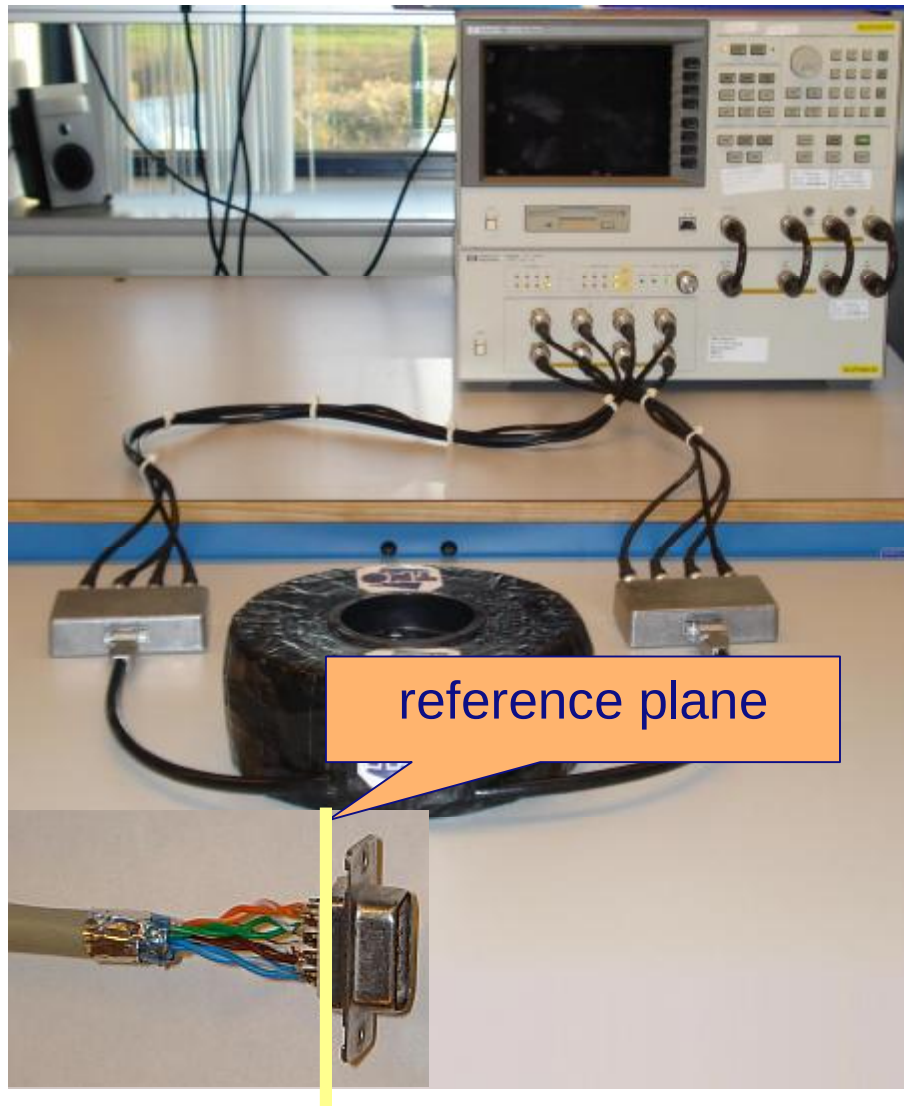
à European consortium: “Enabling 4GGB”, (2009-2011)

3. Multiport cable measurement setup, up to 500 MHz



Measurement setup

3. Multiport cable measurement setup, up to 500 MHz

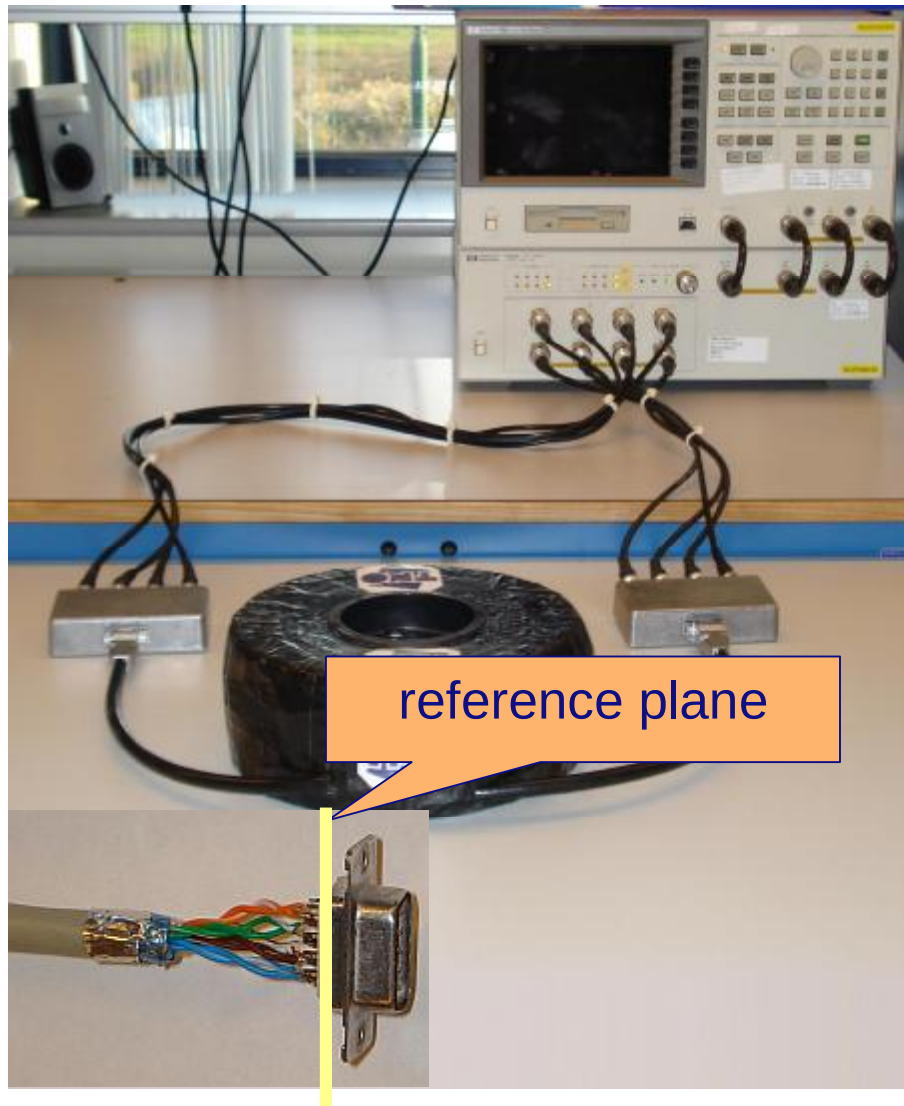


Key problem:

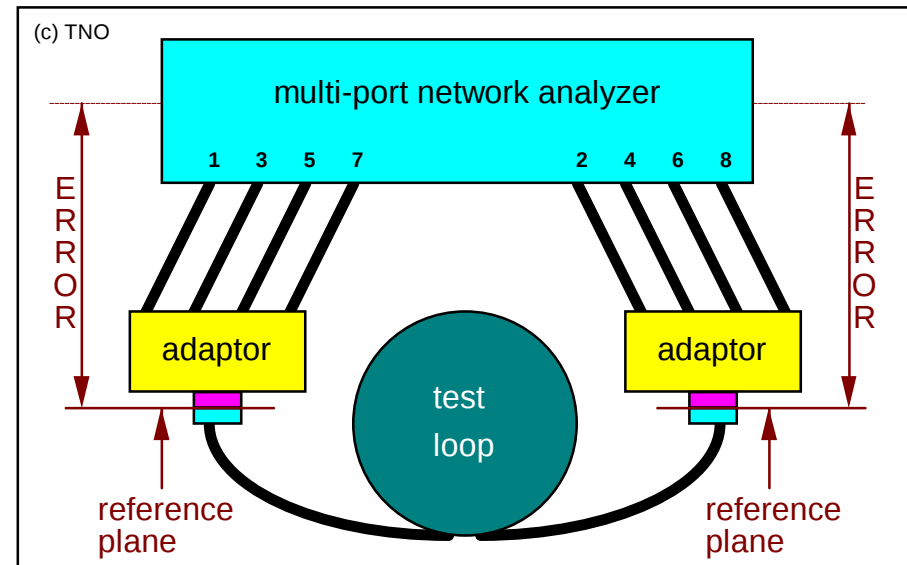
Instrument does not measure
what I would like to know!

Measurement setup

3. Multiport cable measurement setup, up to 500 MHz

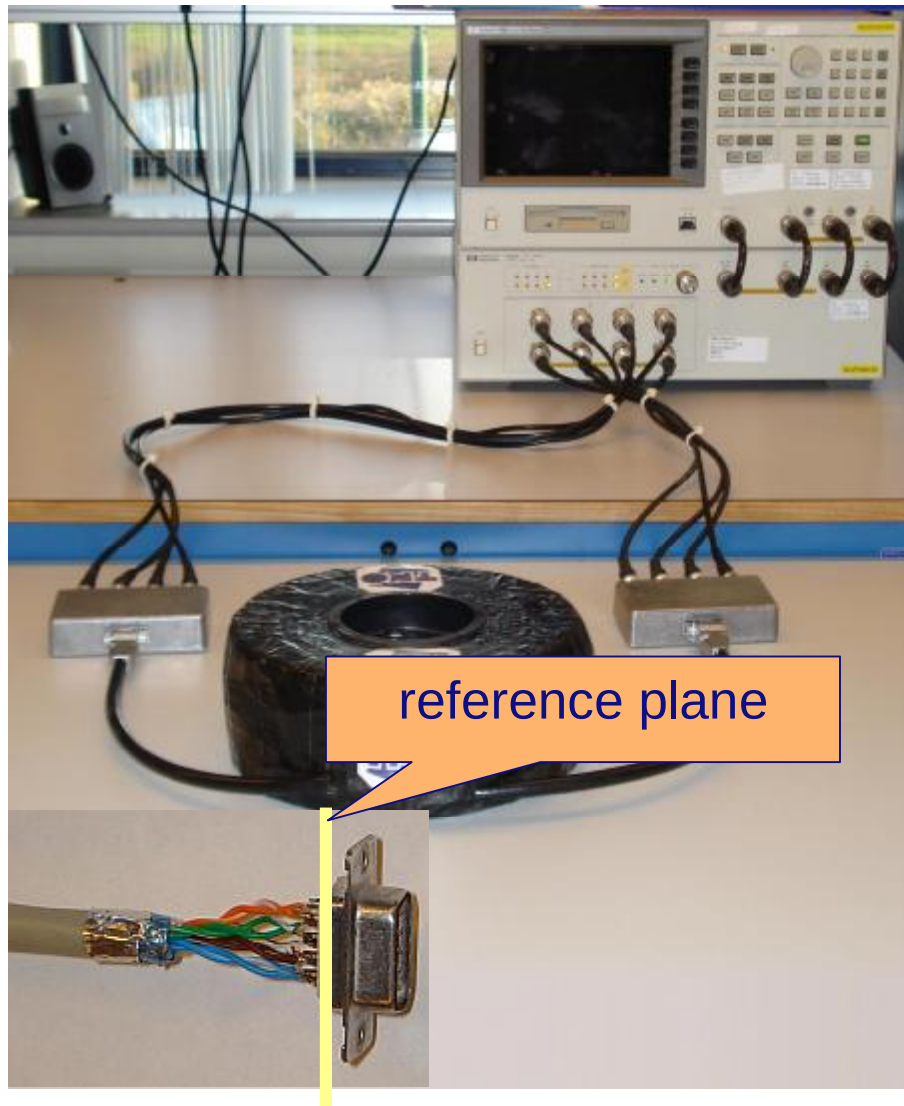


Measurement setup

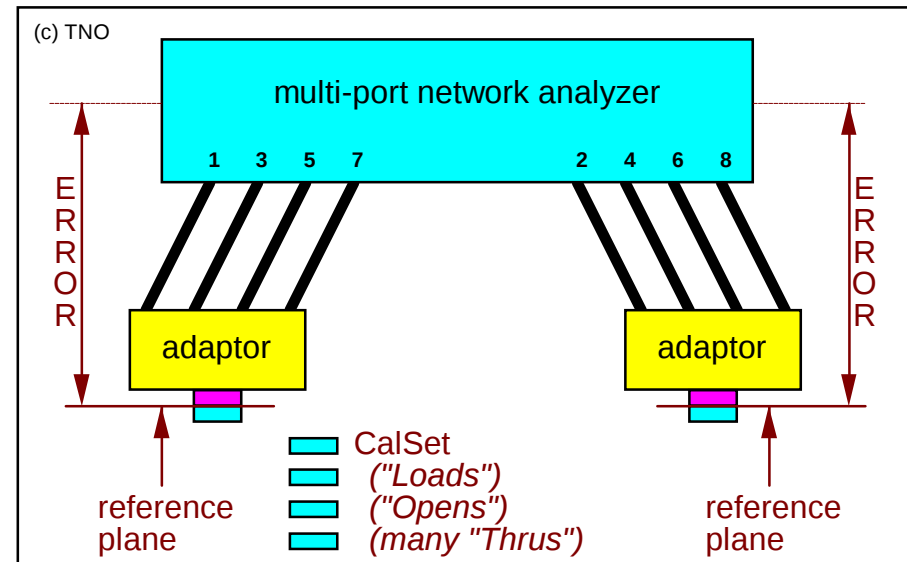


schematic diagram

3. Multiport cable measurement setup, up to 500 MHz



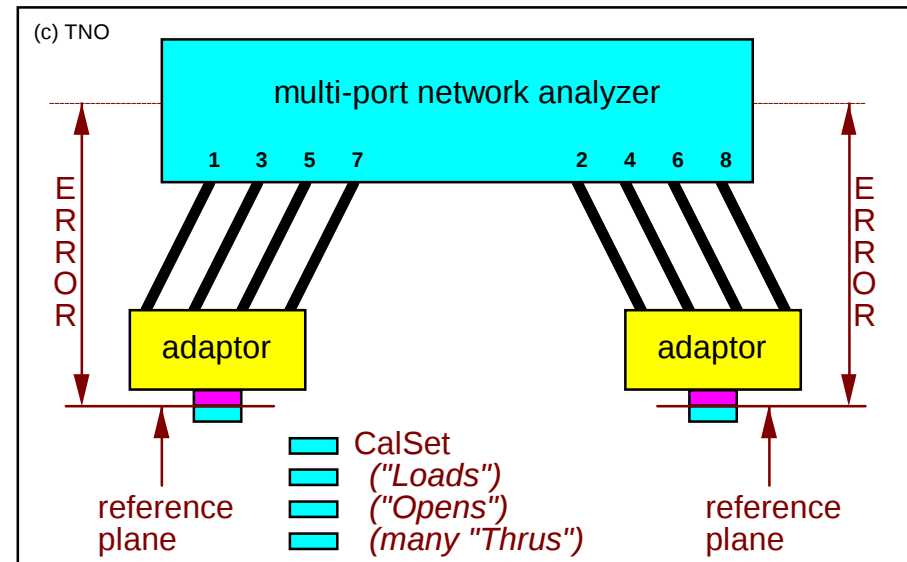
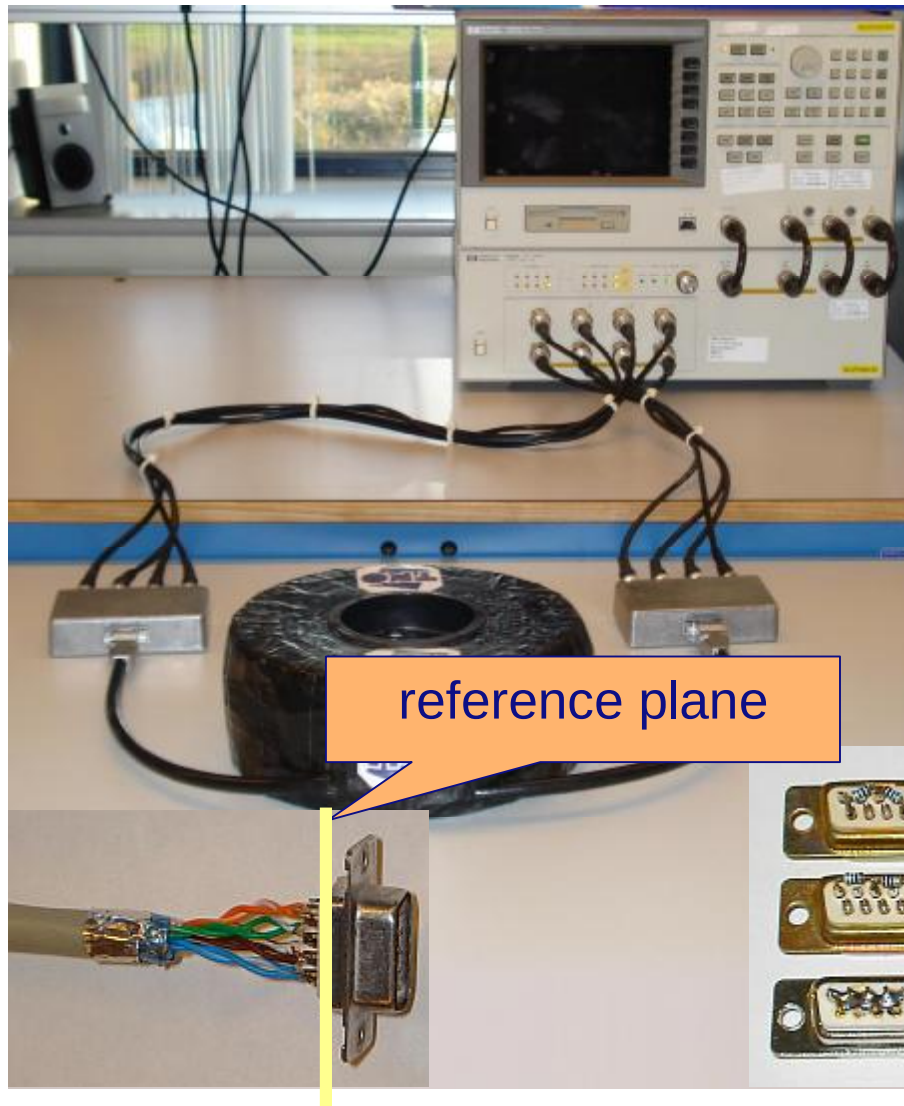
Measurement setup



use known networks to measure the errors, and to correct for it via software post-processing ...

solve 140 equations to find 48 unknown (for each frequency)

3. Multiport cable measurement setup, up to 500 MHz



use known networks



Measurement setup

calibration set, for error correction

3. Multiport cable measurement setup, up to 500 MHz

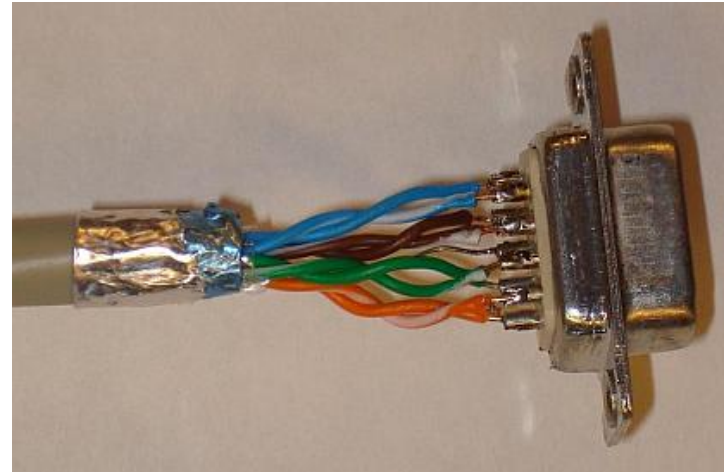


Measurement setup

calibration set, for error correction

4. Characterizing high quality cables (CAT5)

- CAT5-quality
- 4 twisted-pairs
- shielded
- intended for Gb Ethernet networks



232m, CAT5, 4 twisted-pairs

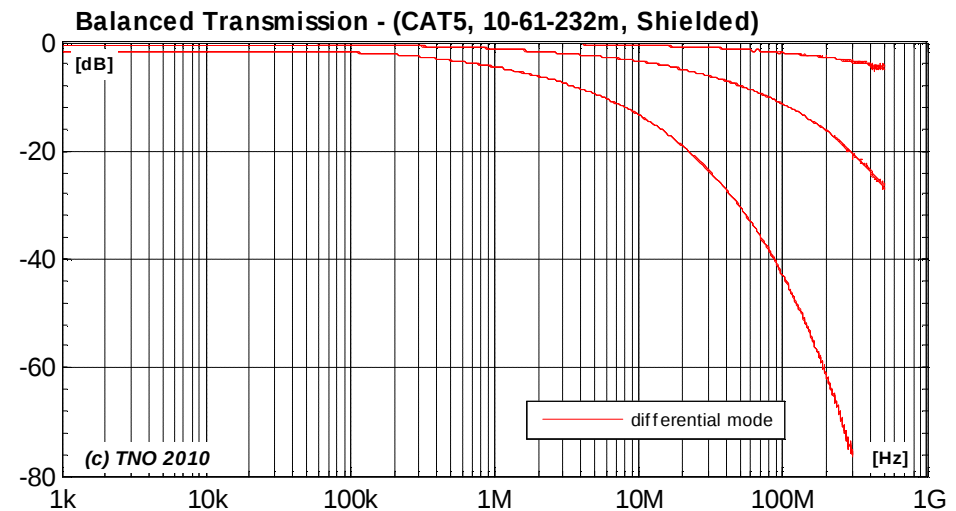
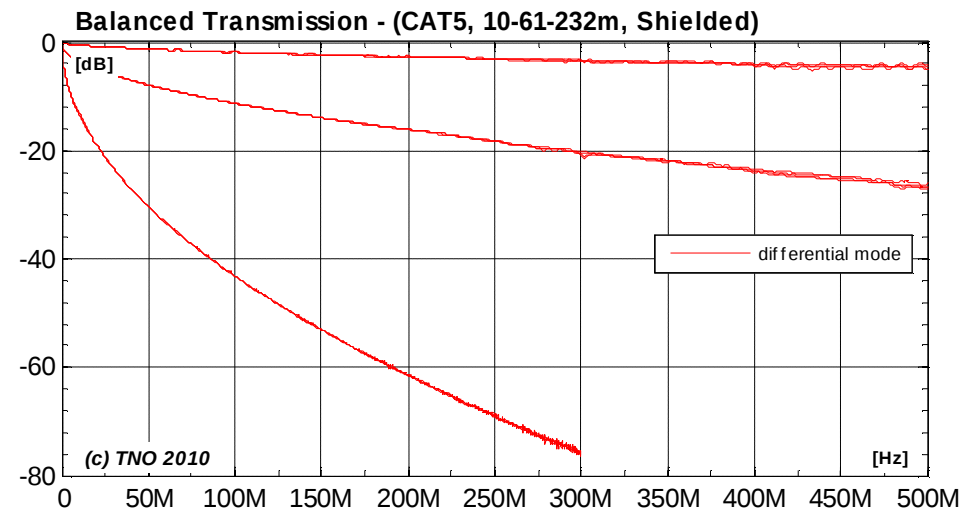


61m, CAT5, 4 twisted-pairs

4. Characterizing high quality cables (CAT5)

Balanced Transmission:

5.7 dB / 100m @ 10MHz
18.6 dB / 100m @ 100MHz



4. Characterizing high quality cables (CAT5)

Balanced EL-FEXT Crosstalk:
much better than “excellent”

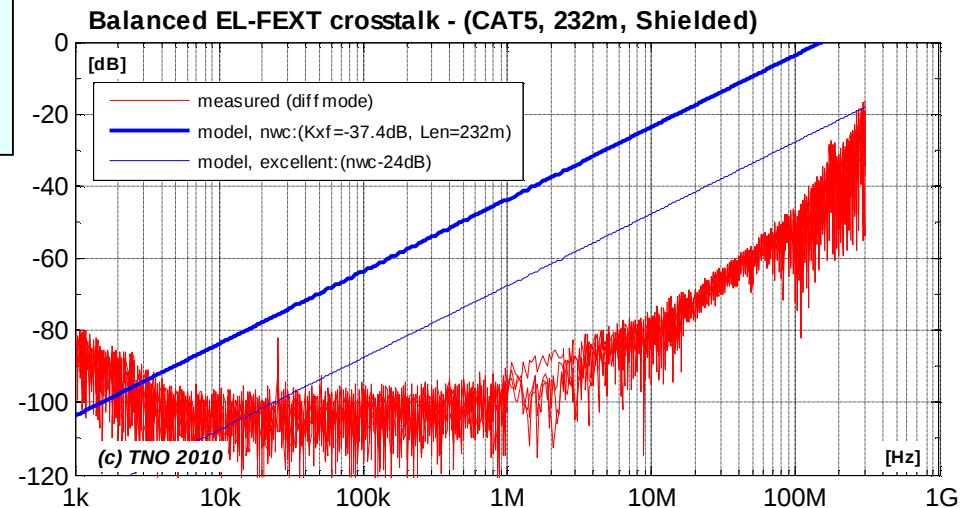
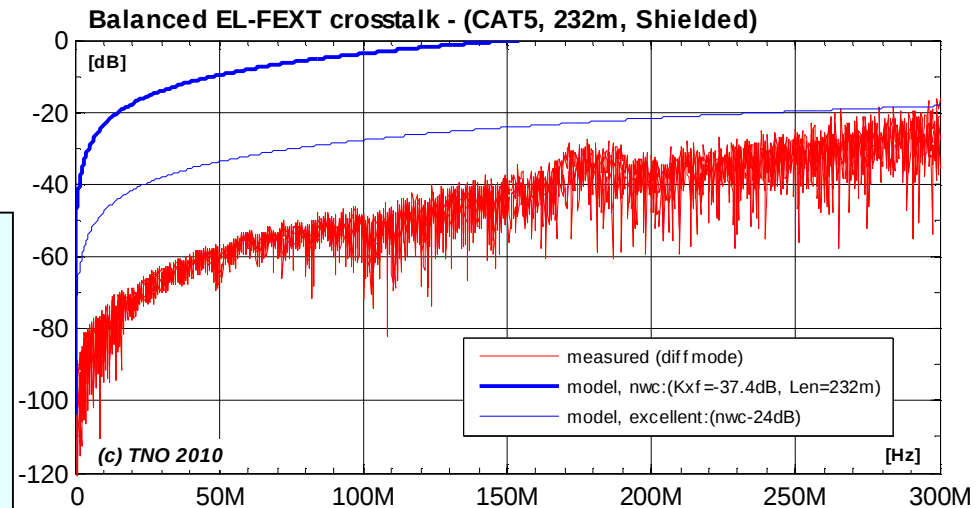
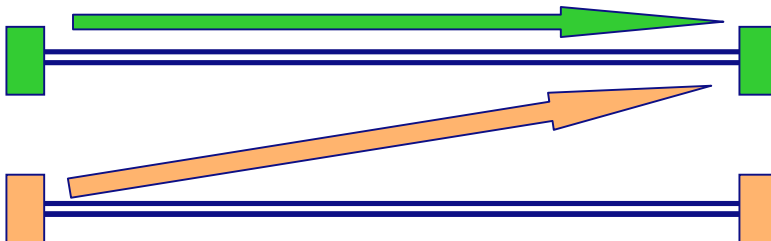
Theoretical bitrates:

use of VDSL2, 30 MHz spectra:
use of 2 bonded pairs (“quads”)
use of classic simulation models

- 50m à >500 Mb/s

- 200m à >460 Mb/s

more with dedicated DSL / G.hn

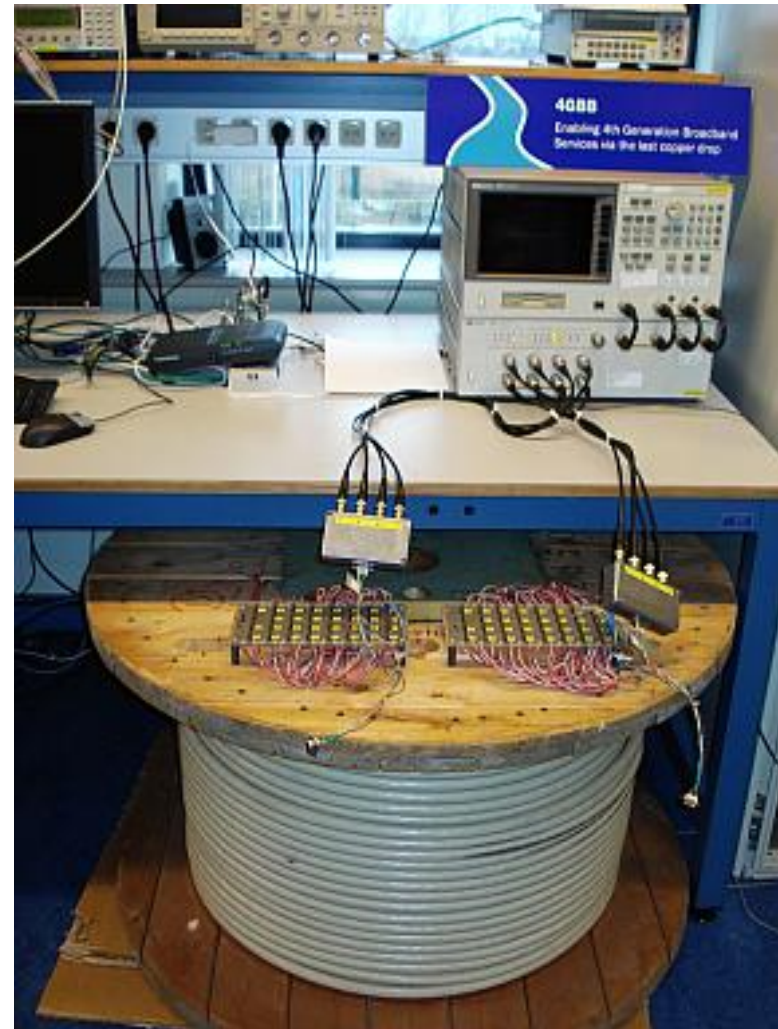


4. Characterizing medium quality cables (telephony)

- 30 twisted-quads (2×2 pair)
- shielded
- telephony wiring for buildings



interconnection with measurement setup

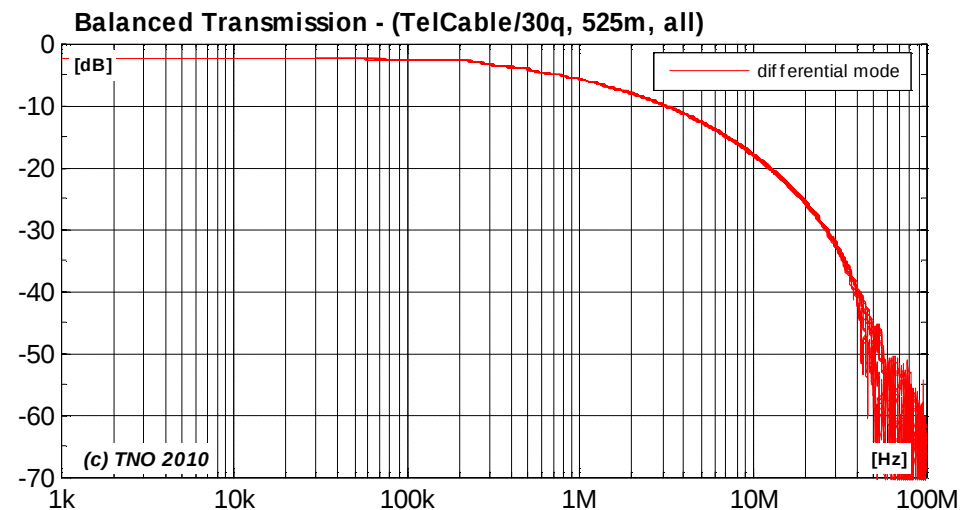
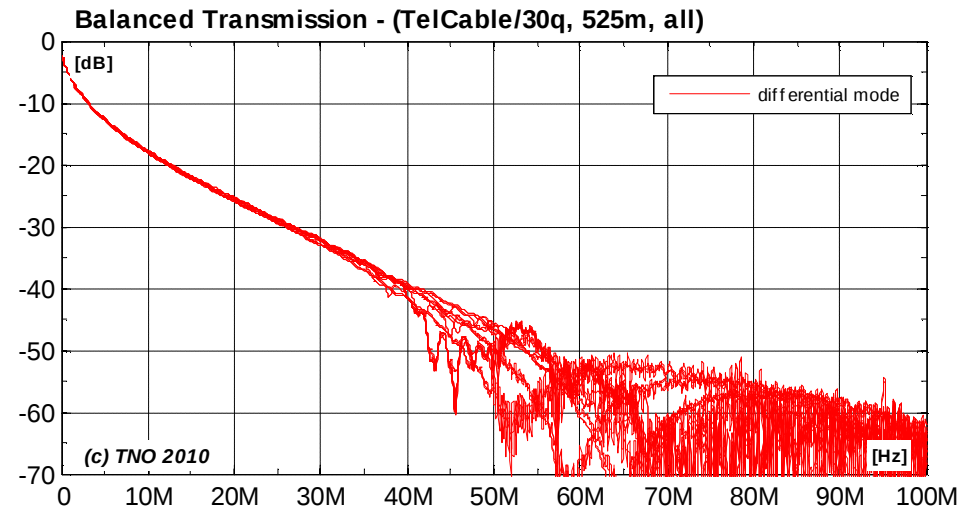
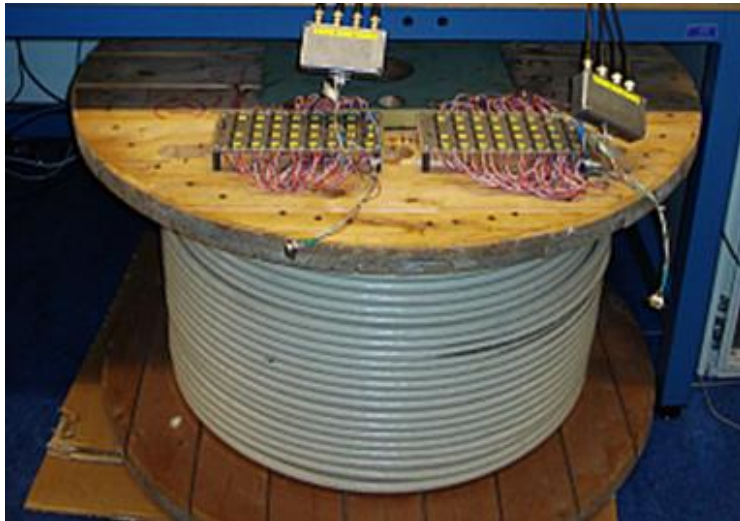


525m on a drum

4. Characterizing medium quality cables (telephony)

Balanced Transmission:

3.5 dB / 100m @ 10MHz
13 dB / 100m @ 100MHz



4. Characterizing medium quality cables (telephony)

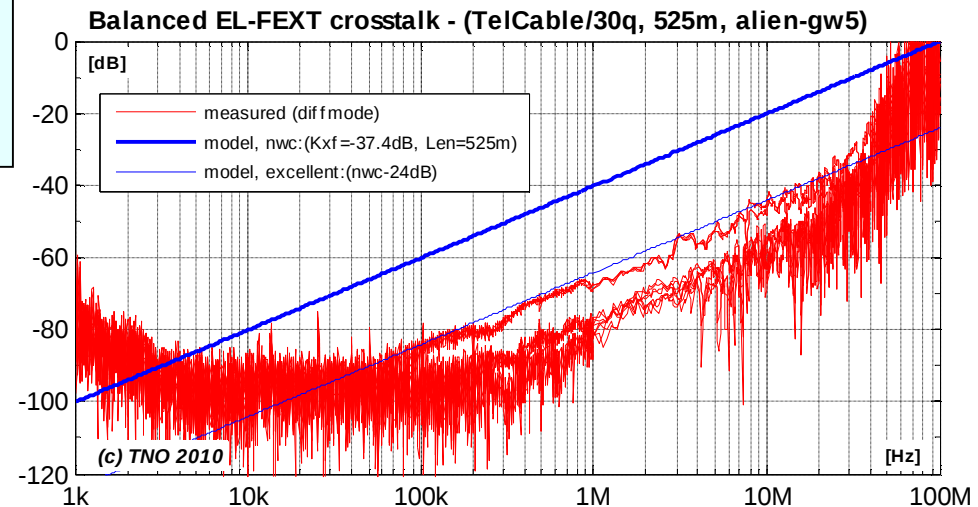
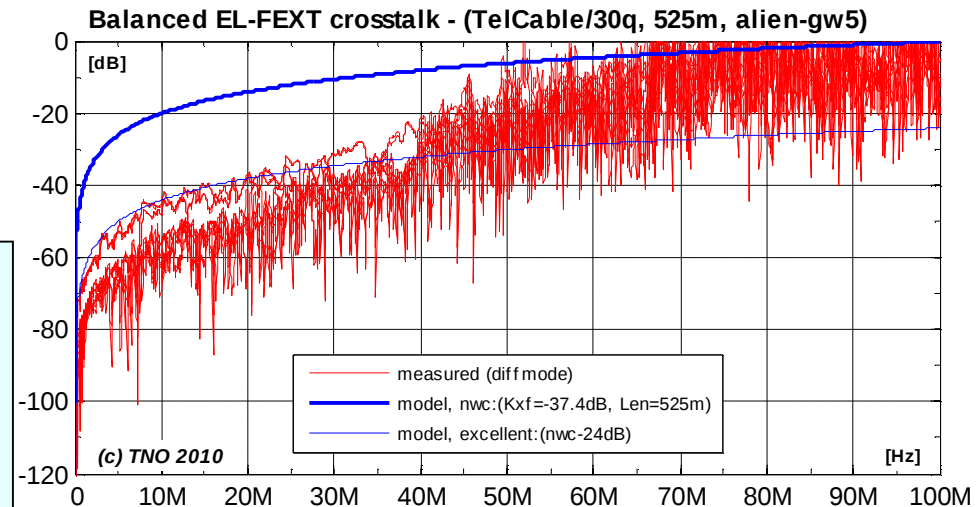
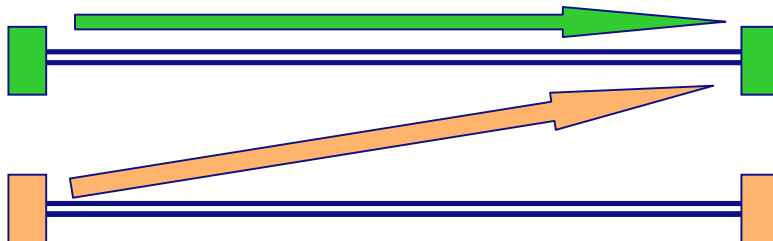
Balanced EL-FEXT Crosstalk:
“excellent” quality

Theoretical bitrates:

use of VDSL2, 30 MHz spectra:
use of 2 bonded pairs (“quads”)
use of classic simulation models

- 50m à >350 Mb/s
- 200m à >280 Mb/s

more with dedicated DSL / G.hn

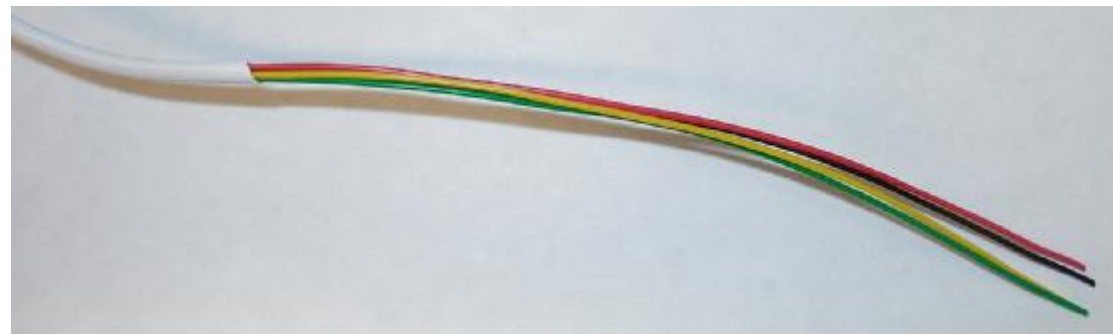


4. Characterizing low quality cables (very cheap)

- fully untwisted
- fully undefined “telephony wiring”
- unshielded
- found in consumer shop “GAMMA”
- 25m

Gamma			
Lammenschansweg 130 2321 JX LEIDEN +31 71 5315147			
Klantenkaart: 251100609018			
AGENT OMSCHRIJVING	PRIJS	BEDEAG	BTW
1 HOEK ALUMINIUM 25x25x2MM 1M	4,79	4,79	1
4 TELEFOONKABEL RMD 800.5MM 25M	5,99	23,96	1
1 GAMMA BIG SHOPPER	1,00	1,00	1
1 BERKEN MULTIPLEX 16MM 122X61CM	18,48	18,48	1
7 Totaal		48,24	
Pin		48,24	

BETALINGSDAG			
Datum	27/01/10 Tijd	16:09:23	
Kassa nr	YMB106	Referentie	01091441
Totaal	48,24	EUR	
Tlv	0315638842		
BANK	Bet.konwark	027NUT	
Acquirer identifier	67300110		
U HEEFT IN TOEGE TOT 23:15			

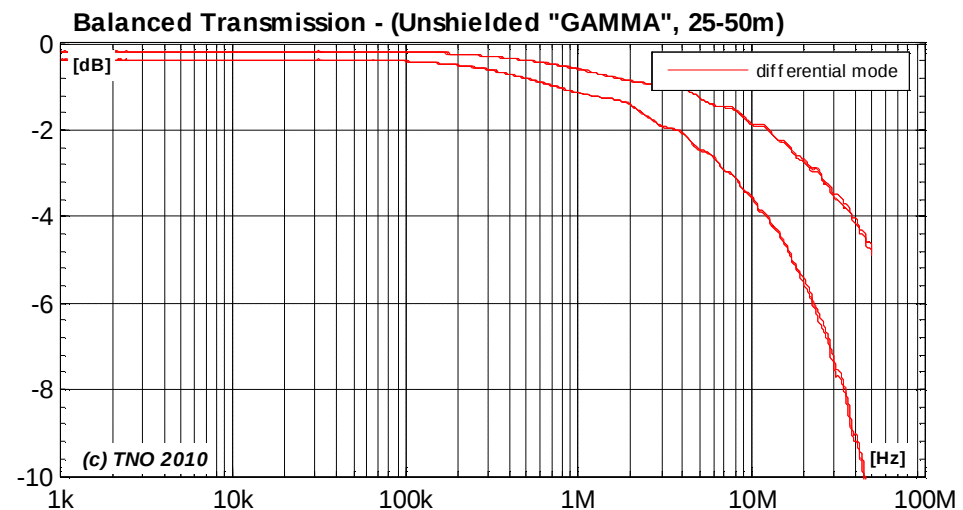
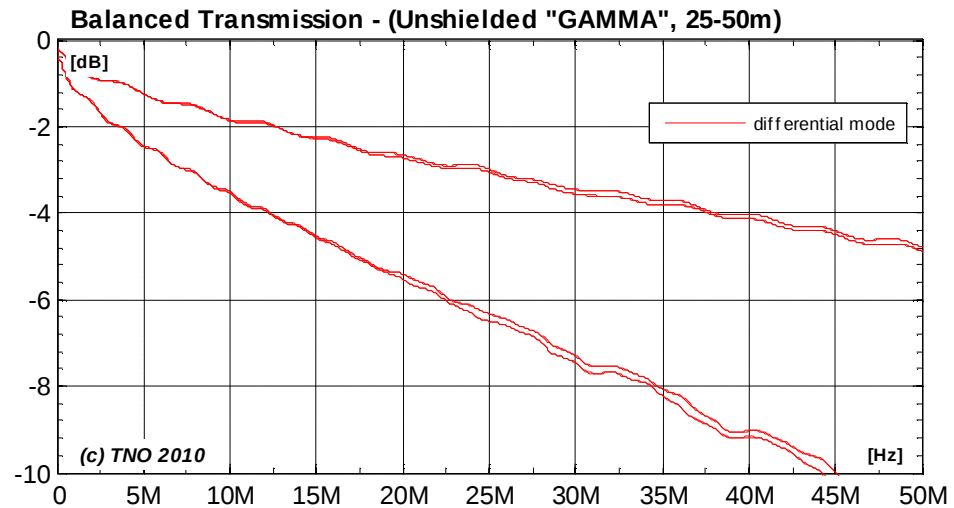


25m or 25+25m spread-out on the floor

4. Characterizing low quality cables (telephony)

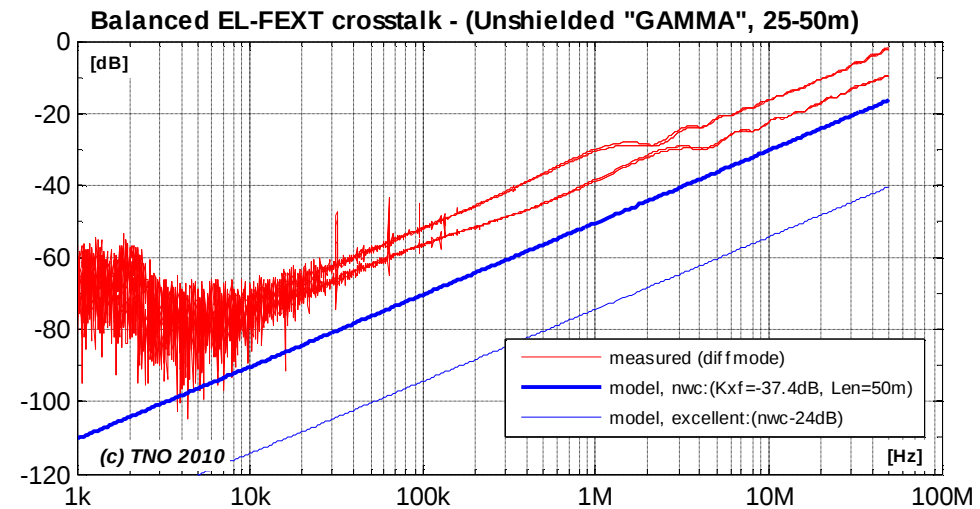
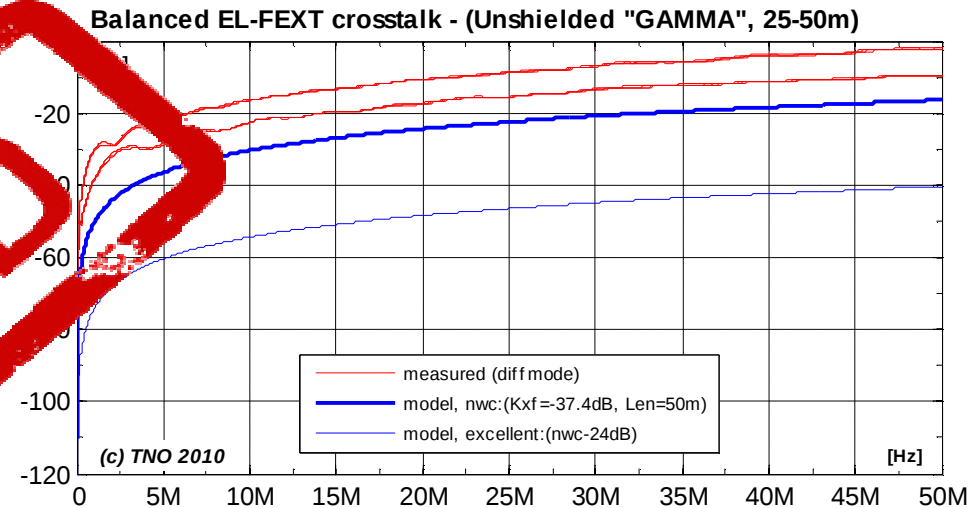
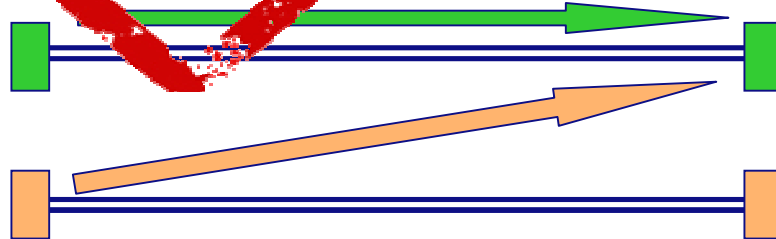
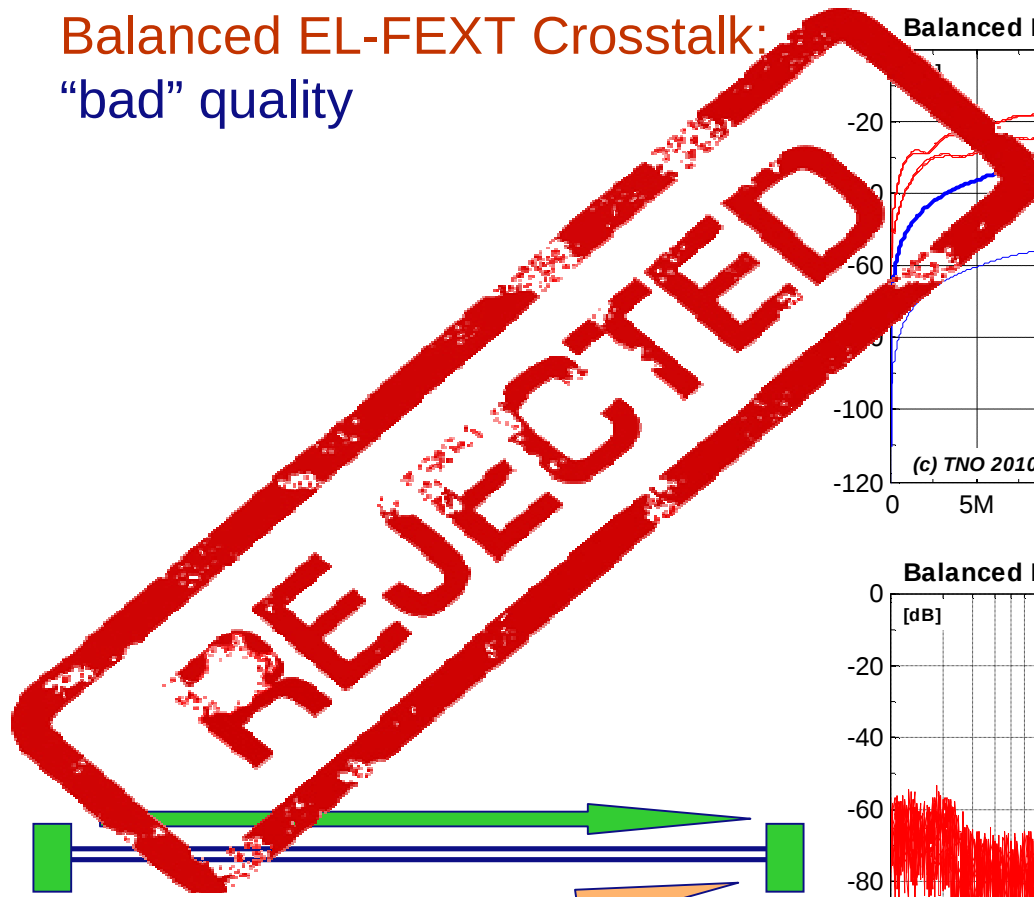
Balanced Transmission:

7 dB / 100m @ 10MHz
40 dB / 100m @ 100MHz



4. Characterizing low quality cables (telephony)

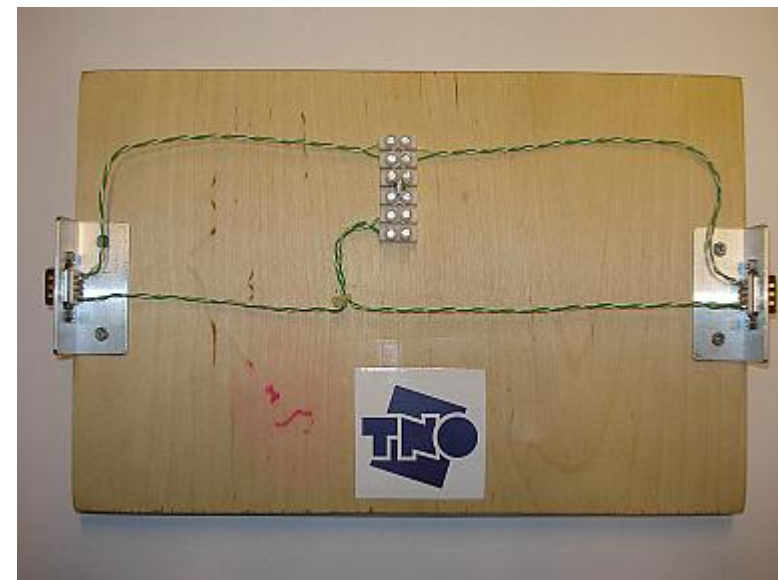
Balanced EL-FEXT Crosstalk:
“bad” quality



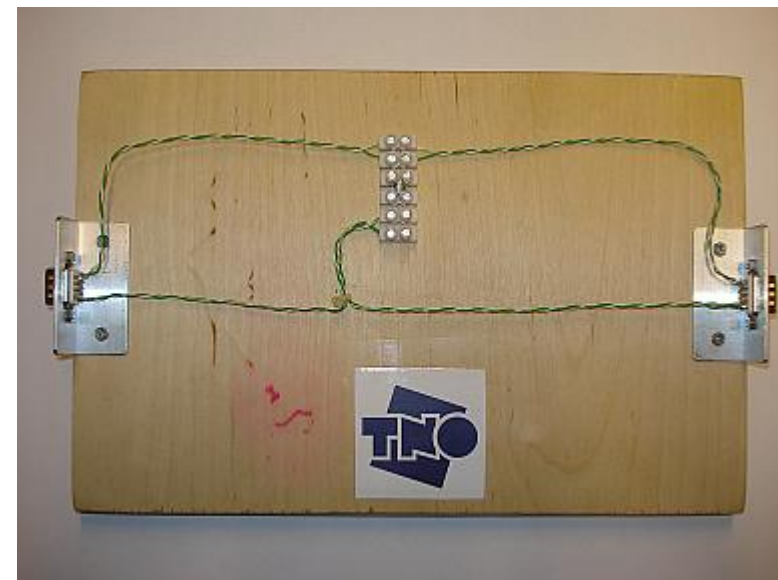
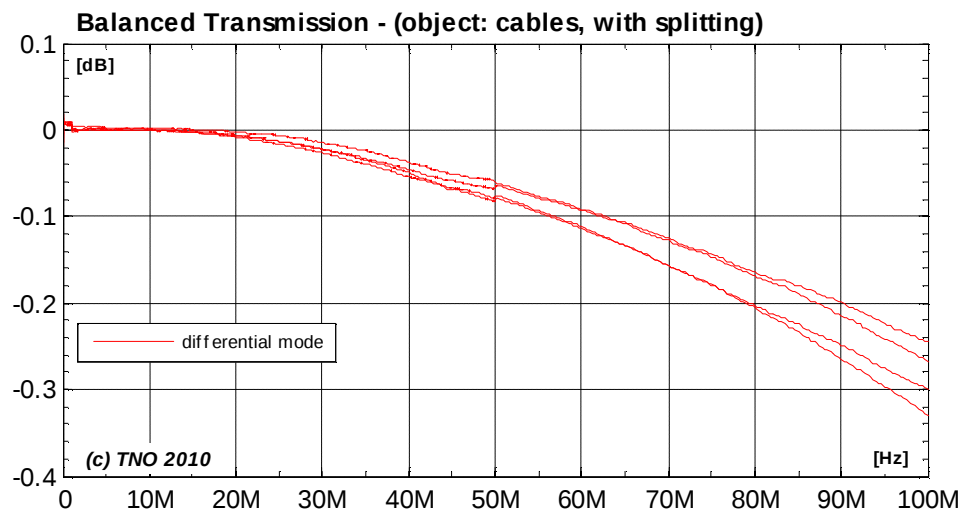
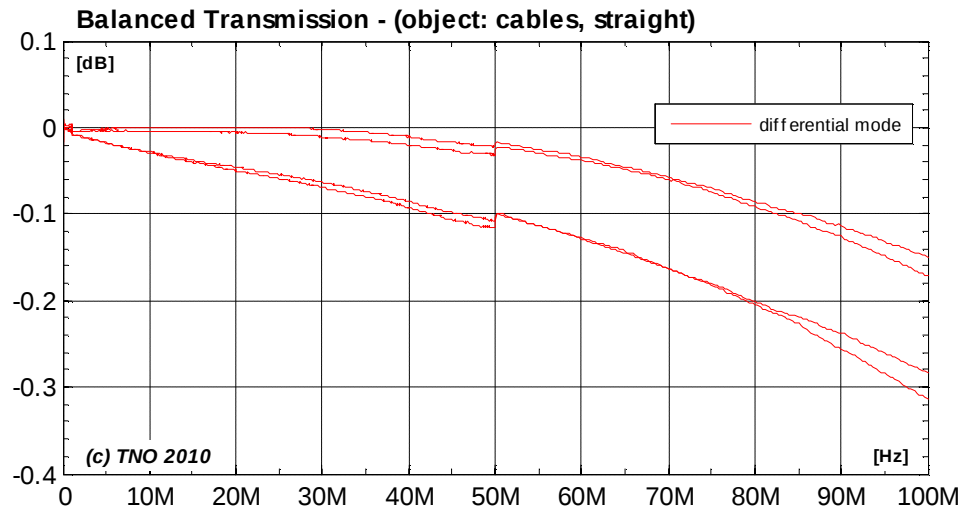
4. Characterizing splices and other obstacles

Replica's from common practice

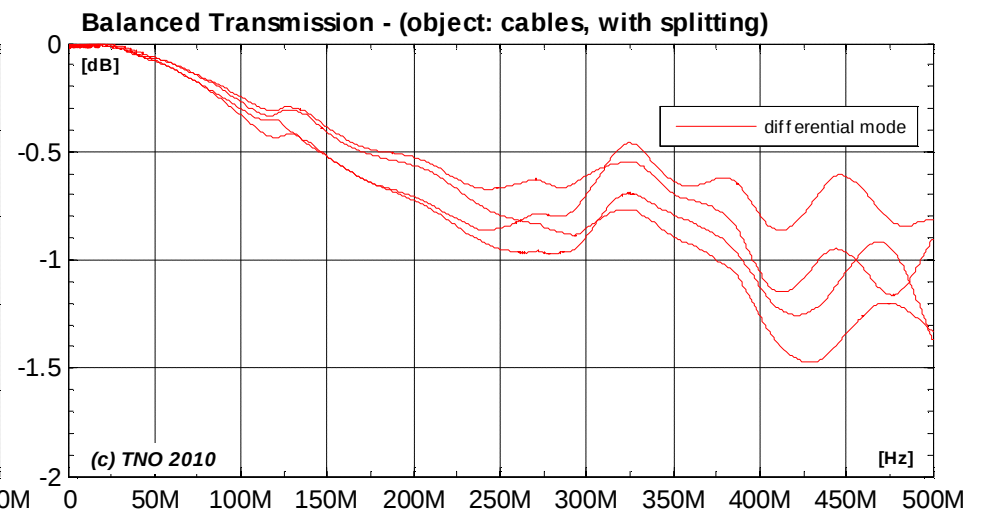
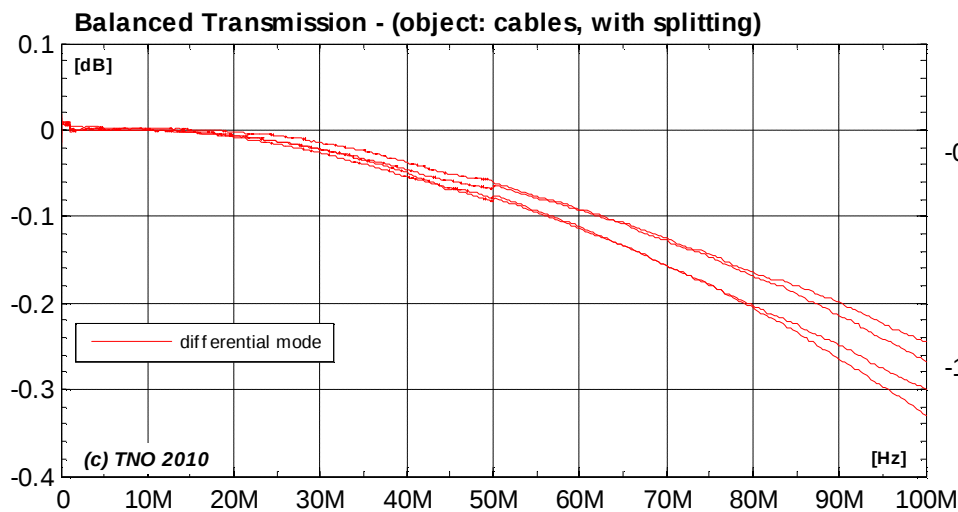
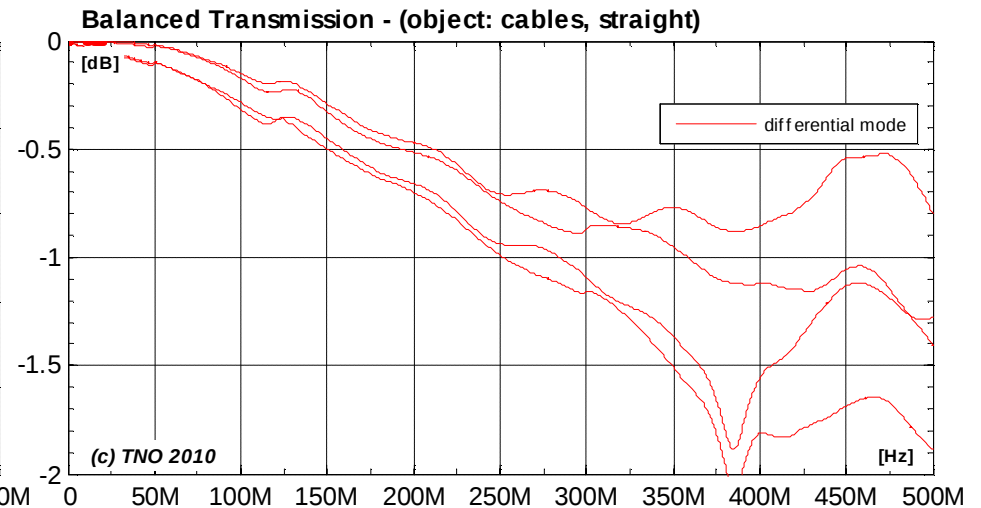
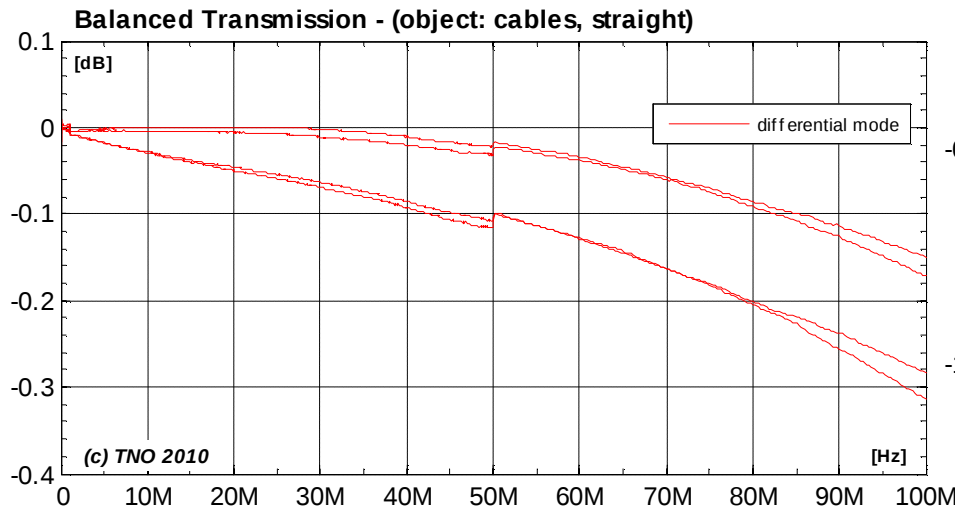
- straight untwisted pair
- straight twisted pair
- interconnection (“home brew”)
- simulation of a cable splice



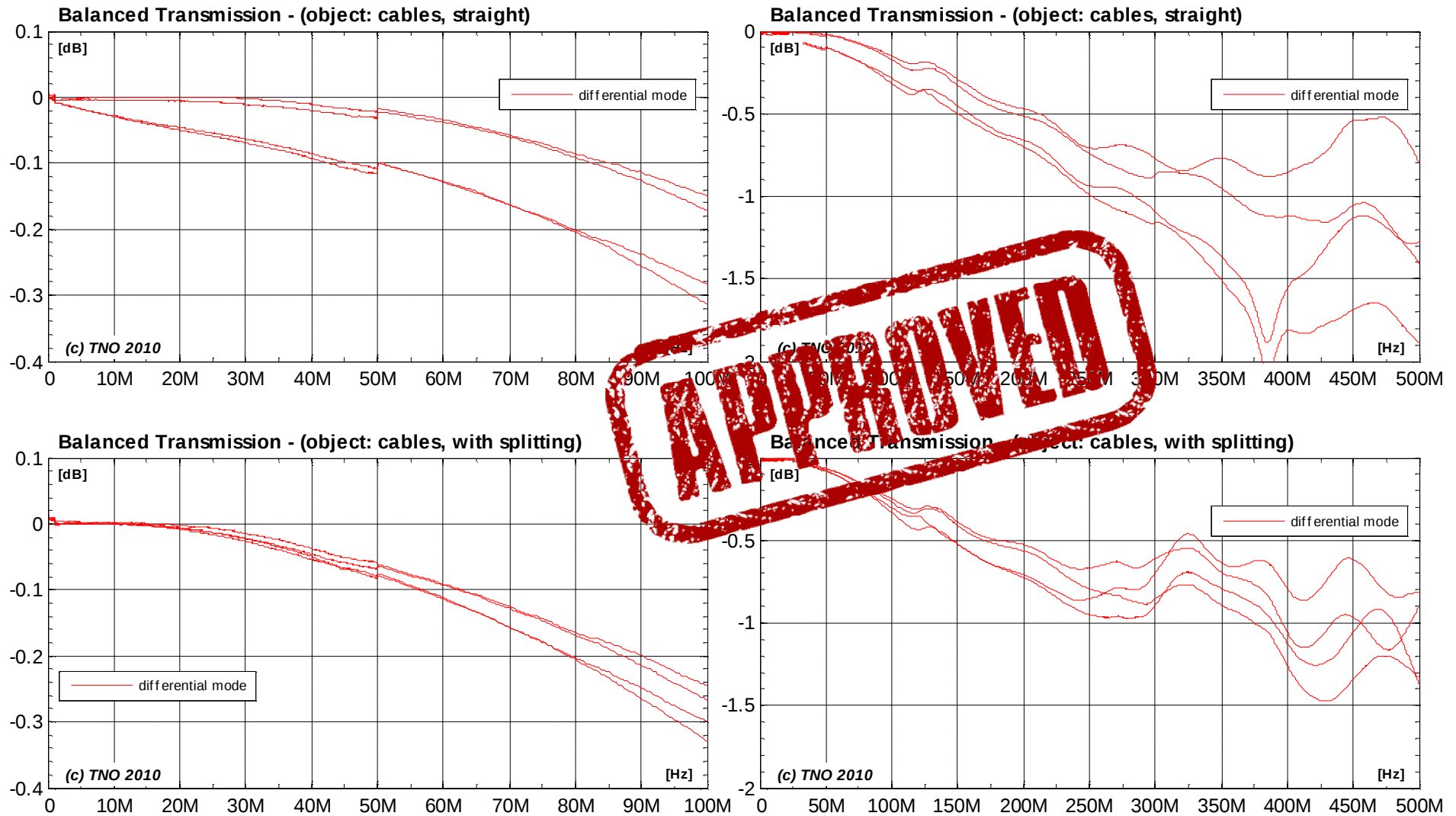
4. Characterizing splices and other obstacles



4. Characterizing splices and other obstacles



4. Characterizing splices and other obstacles



5. Further actions, for the next two years

- Techno-economic studies
 - when and where is it attractive?
 - quantifying cost-savings
- Further characterization of access network
 - operational cables/installation
 - noise, ingress, egress, etc
 - modeling, prediction of bitrates
- Development of dedicated DSL technologies
 - by other partners in 4GBB/Celtic consortium
- Bring the industry in motion
 - gain more interest from industry & operators
 - initiation of standards
 - publicity: DSL seminar, (white) papers, tweakers.net, ...

6. Conclusions

enabling 4GBB via hybrid FttH:

- FttH via hybrid fiber/copper is an attractive option
 - might be more effective in cost for several cases (20%?, 30%?, ...)
 - might be faster to install for several cases
 - might lower the threshold for offering 4GBB speeds
- FttH via hybrid fiber/copper is technically feasible
 - the first cable measurements made this plausible
 - its essentially a mix of Gb/s Ethernet and DSL solutions
- FttH via hybrid fiber/copper concept applicable today
 - 30MHz variants of VDSL2 already standardized
 - G.hn is also a possibility
 - many customer premises connected via quads for 2 bonded pairs
 - targeted for existing wiring in apartment buildings

FttH is more than just fiber!



4GBB/CELTIC Consortium



CELTIC
Telecommunication Solutions



ERICSSON



Telefonica



france telecom
R&D

Actelis
Networks™



upZide

robotiker
tecnalia





Back-up slides

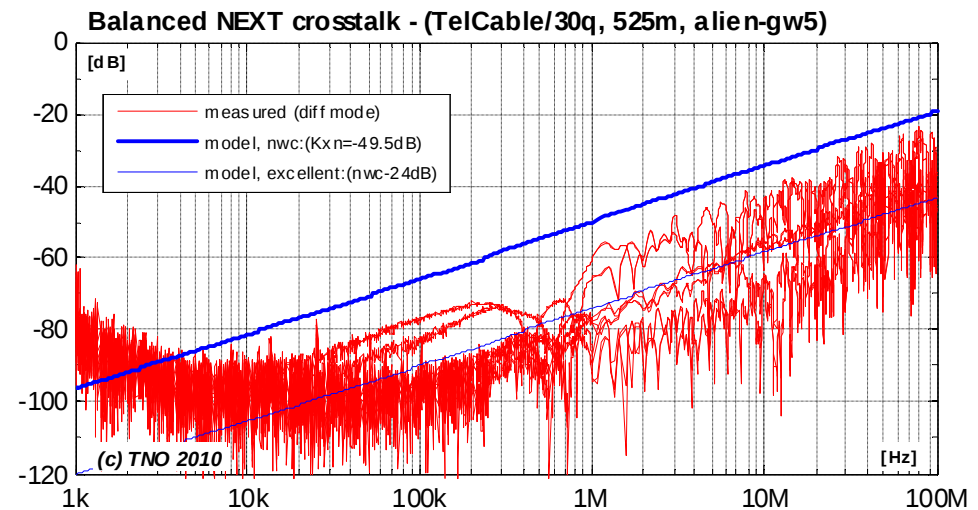
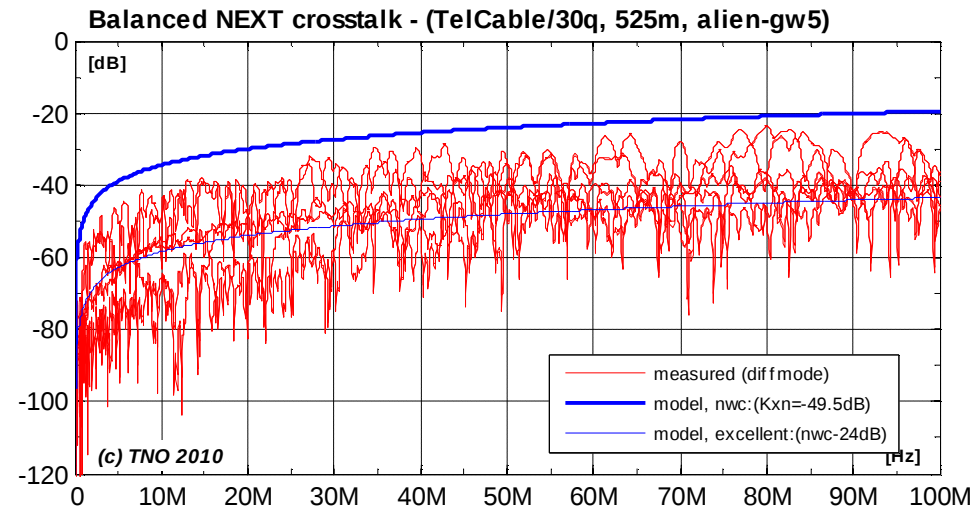
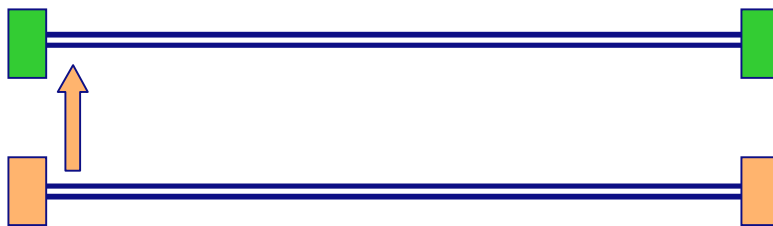
TNO | Kennis voor zaken



dr. Rob F.M. van den Brink - Enabling 4GBB, the next generation broadband

4. Characterizing medium quality cables (telephony)

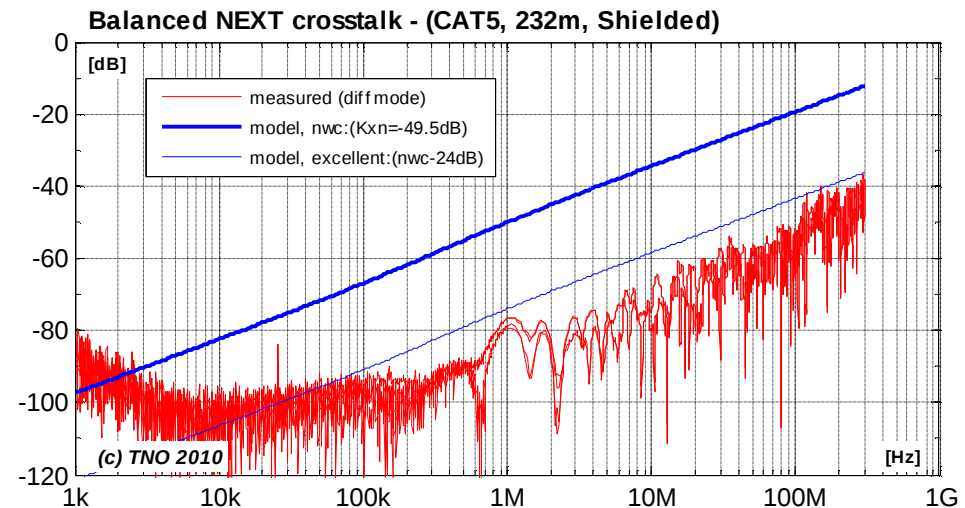
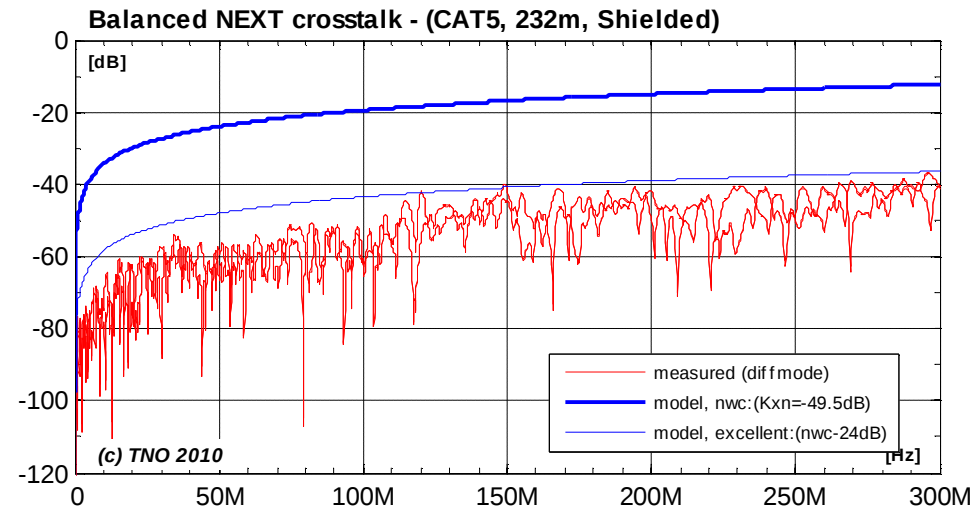
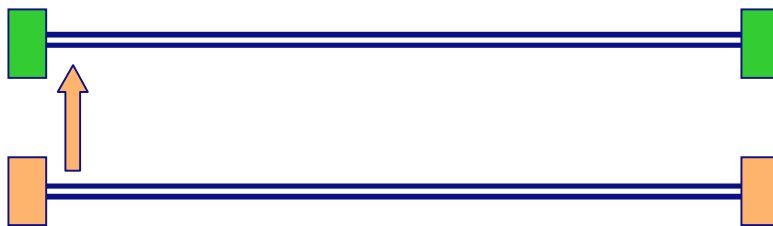
Balanced NEXT Crosstalk:
typical telephony quality



4. Characterizing high quality cables (CAT5)

Balanced NEXT Crosstalk:

better then “excellent”



4. Characterizing low quality cables (telephony)

Balanced NEXT Crosstalk:

“bad” quality

