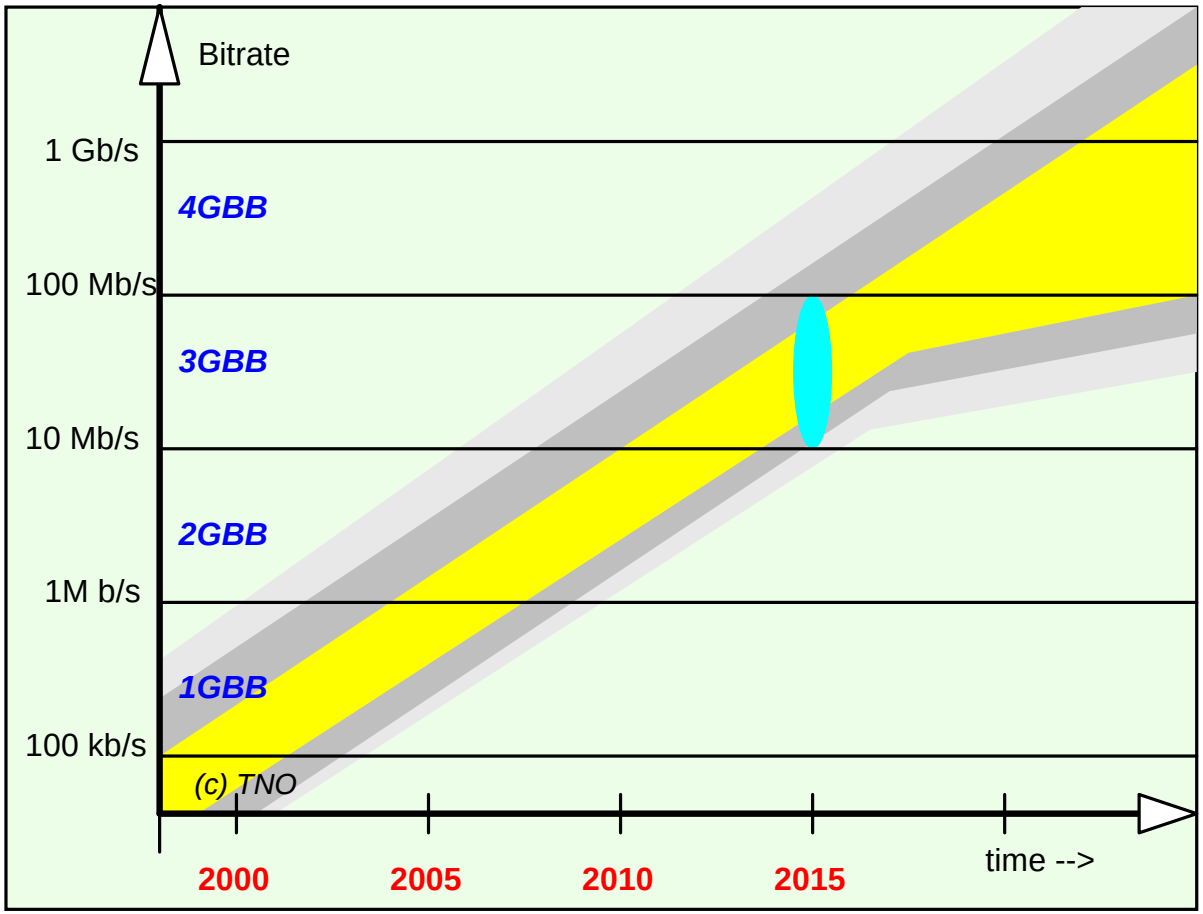
Broadband technologies for the next generation in copper

VDSL/35b (Vplus, SuperVectoring, E-VDSL) and G.fast

dr. ir. Rob F.M. van den Brink – TNO

1. Higher bitrates? **à** Demand keeps growing



Higher bitrates?

à "WBA200" will soon needs a follow-up (400, 800?)

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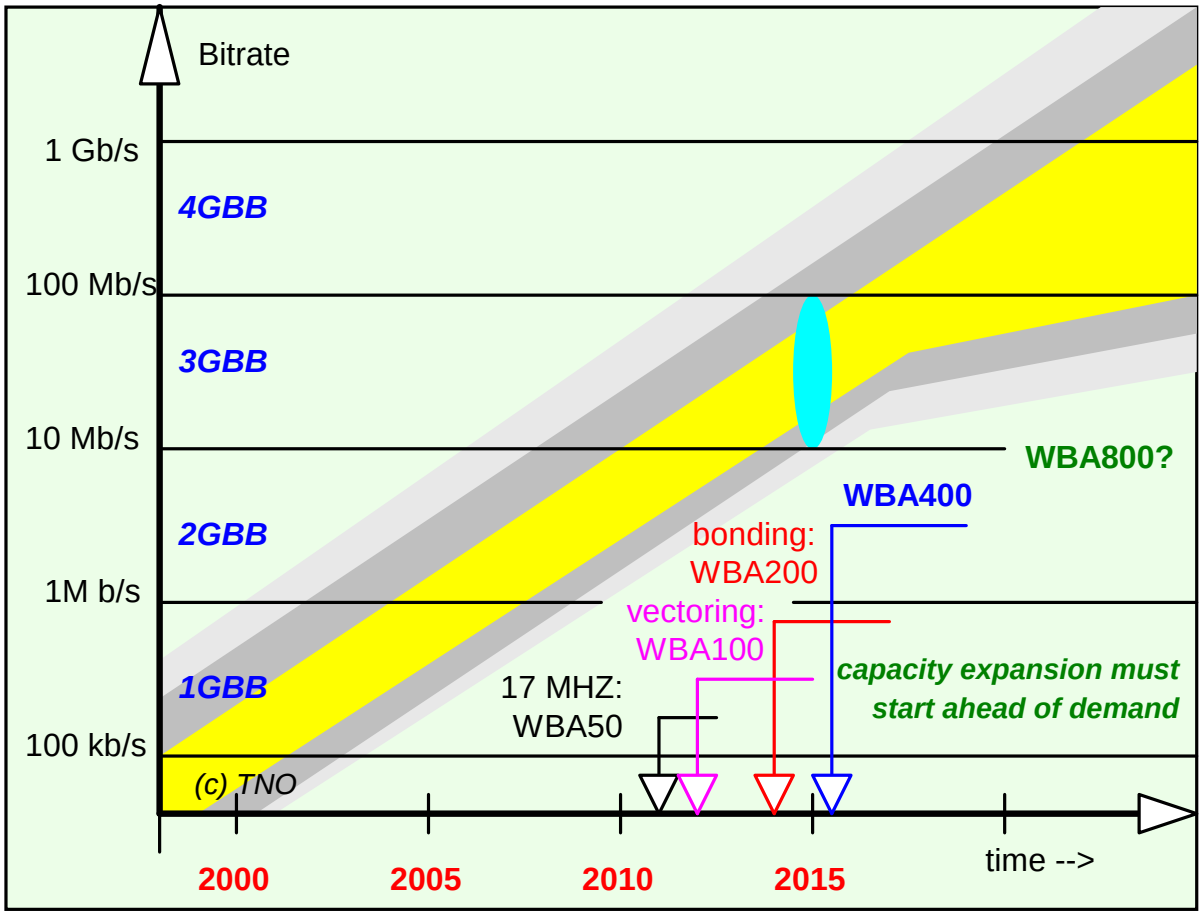


Higher bitrates?

à "WBA200" will soon needs a follow-up (400, 800?)

à Start in time with capacity expansion: WBA400

1. Higher bitrates? **à** different options for copper

Higher bitrates mean:

- Broader spectra (*beyond 17MHz*)
- Typically effective for shorter distances only
  à VDSL/30a is an option (*currently allowed in NL*)

Problem with VDSL/30a:

- VDSL/30a cannot coexist with ***vectored*** VDSL/17a
- It cannot join the vectoring process
- It will disturb significantly, at hardly no benefit
  à *Innovate with new technologies*

1. Higher bitrates? à different options for copper

Compatible with the legacy	Start with something new
Extent existing VDSL, and Accept all restrictions from VDSL	New product standard, and Design according to state of the art
Same management system, same procedures à easy to introduce	New concept à Less easy to introduce
Offers limited improvements	Offers significant improvements
Compatible with VDSL + vectoring	Incompatible with VDSL
Backward interoperable with CPE; new modems only for more BW	All involved CPE's are to be by new ones; even when more BW is not needed
à **VDSL*/35b*** (up to 35 MHz) *branded as Vplus, Super Vectoring, Enhanced VDSL, ..*	à **G.Fast** (up to 106MHz)
Aims at ~300 Mb/s (lab, US+DS) (field: DS:~200Mb/s, 2×DS:~400 Mb/s,bond)	Aims at ~1 Gb/s (lab, US+DS) (field: DS:~550Mb/s, 2×DS:~1100Mb/s,bond)

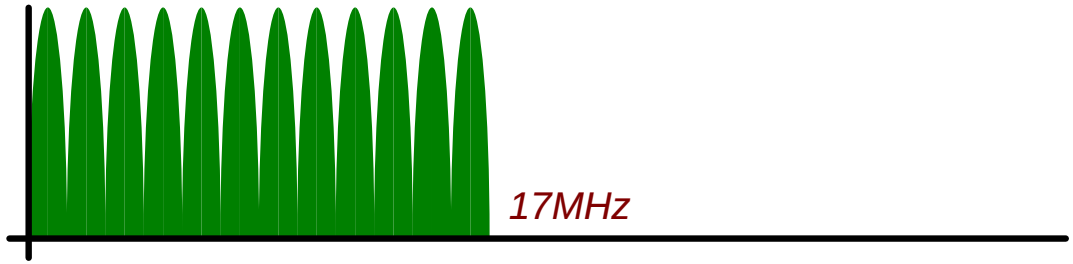
2. New technologies: about VDSL/35b (Vplus)

ADSL(2)
256 carriers

ADSL2plus
512 carriers

VDSL/17a
4096 carriers

ADSL & VDSL signals are build-up
from a plurality of "individual" carriers



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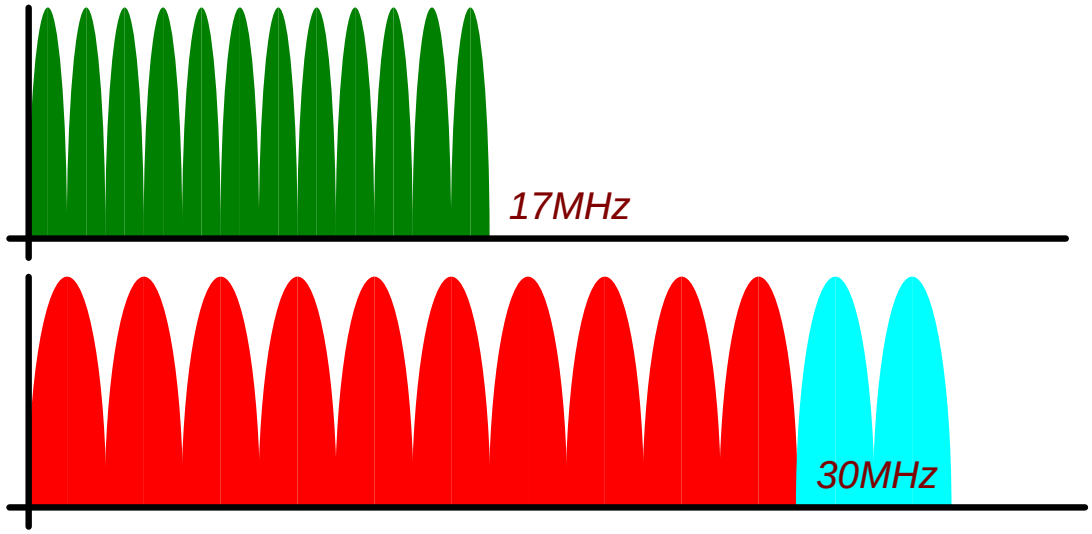

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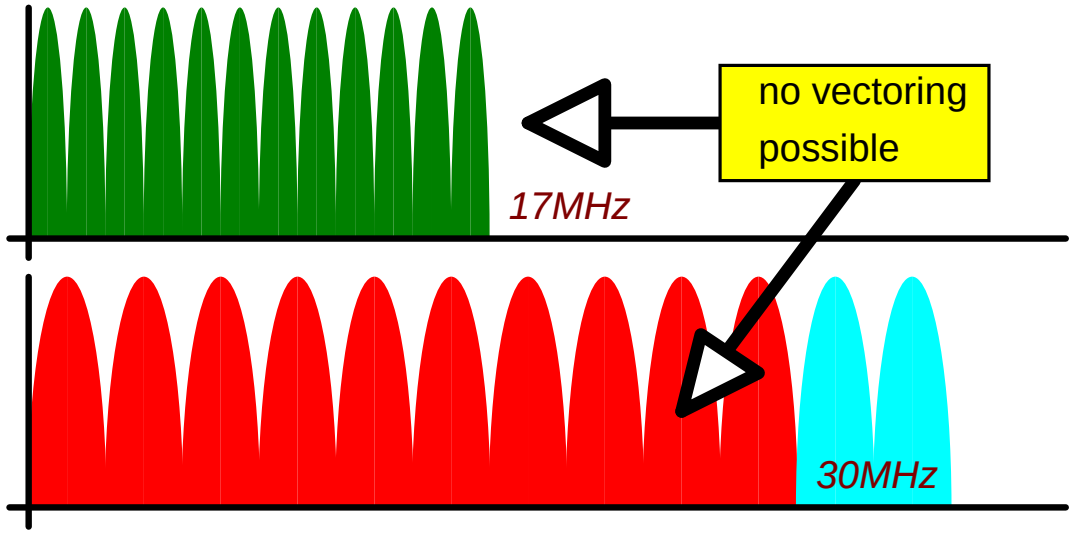

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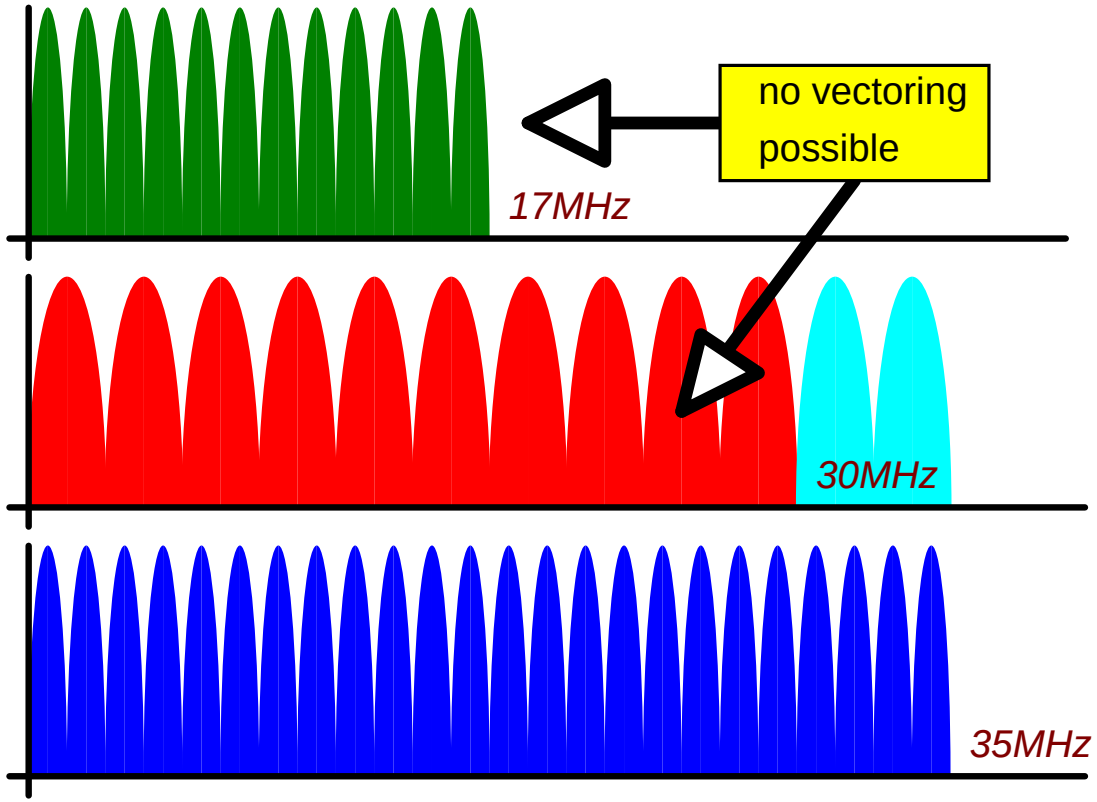

VDSL/17a
4096 carriers

VDSL/30a
4096 carriers

VDSL/35b
8192 carriers

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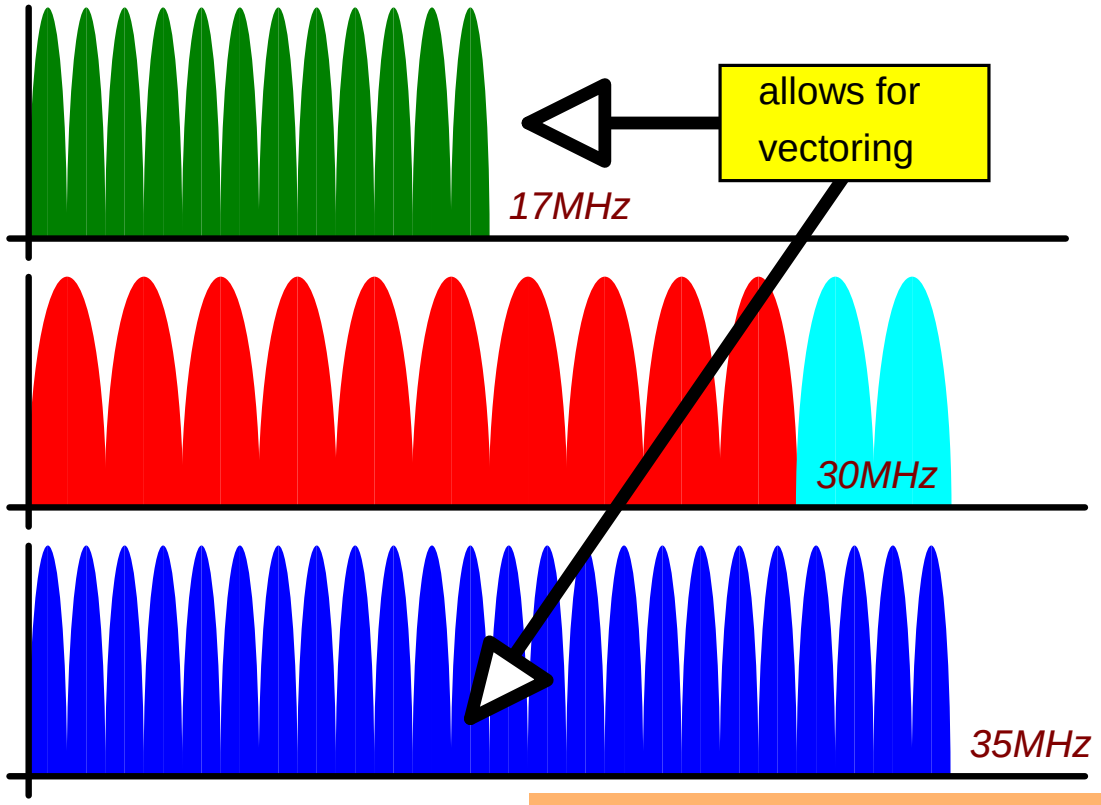


VDSL/17a
4048 carriers

VDSL/30a
4048 carriers

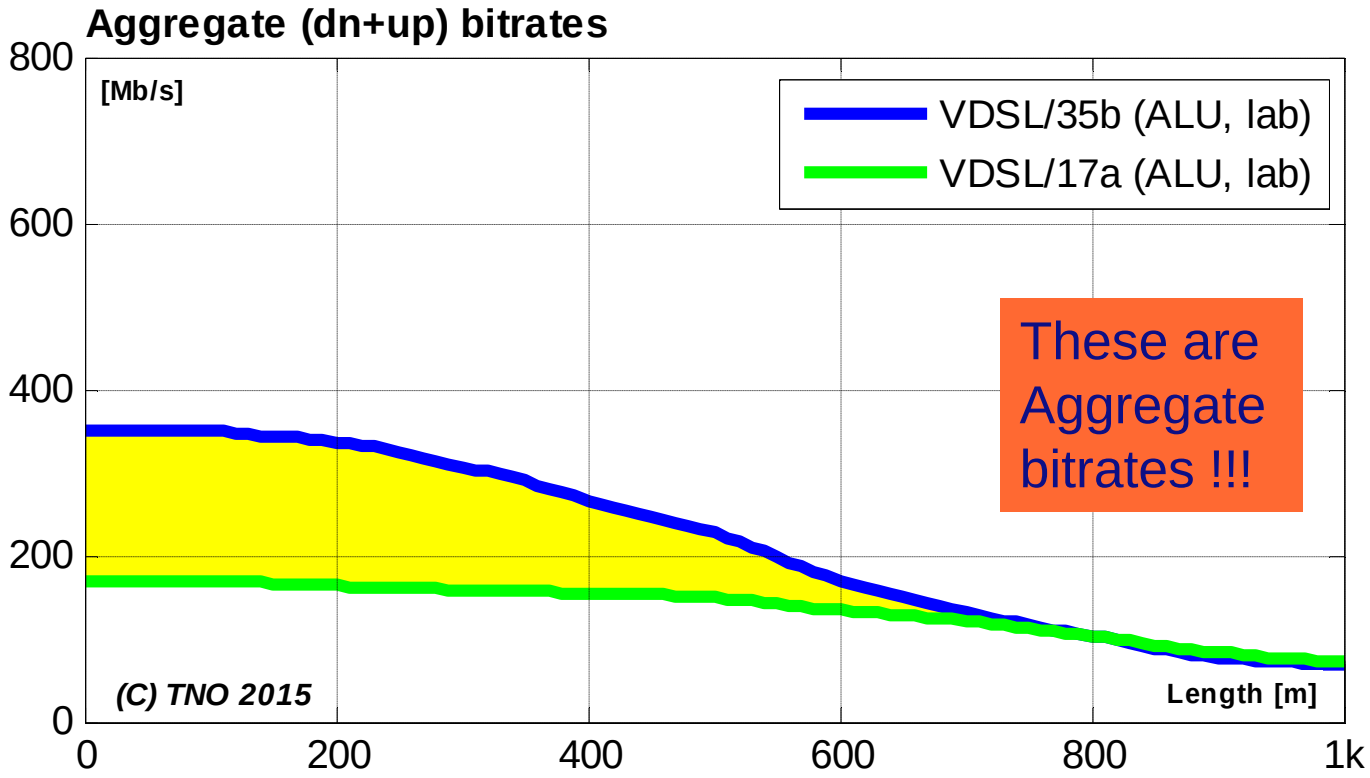
VDSL/35b
8192 carriers

Compatible with VDSL/17:vec

2. New technologies: about G.fast

- G.fast is very different from VDSL:
  - TDD (“ping-pong”) versus FDD (frequency division) to separate down/up
  - Spectrum up to 106MHz (up to 212 MHz in future versions), lower powers
  - Can coexist with VDSL/17a by starting above 17MHz, but this is at the cost of some performance
  - Incompatibe with VDSL/17a, new CPE equipment required, other management system required **à** less convenient to introduce
- All goodies from VDSL implemented and improved in G.fast:
  - Retransmission, *responds more rapidly, lower in latency*
  - Vectoring, *can handle even very high crosstalk levels (higher frequencies!)*
  - Bonding; *can handle bonding when needed*
  - **à** and all designed according to state of the art
- New and improved specs
  - Much higher rates: transmits well over 1Gb/s, with bonding
  - Downstream/upstream rates are adjustable (9:1 to 3:7)
  - More robust due to “Fast Rate Adaptation” (FRA)
  - Low latency retransmission (<1ms)
  - Fast start-up times (~10 seconds) and retrain times (~2 sec)
  - Can even been powered from customer side (“reverse powering”)

2. New technologies: attainable bitrates



Measured bitrates for VDSL/35b

- VDSL/35b lab rates measured by ALU
- VDSL/17a lab rates measured by ALU

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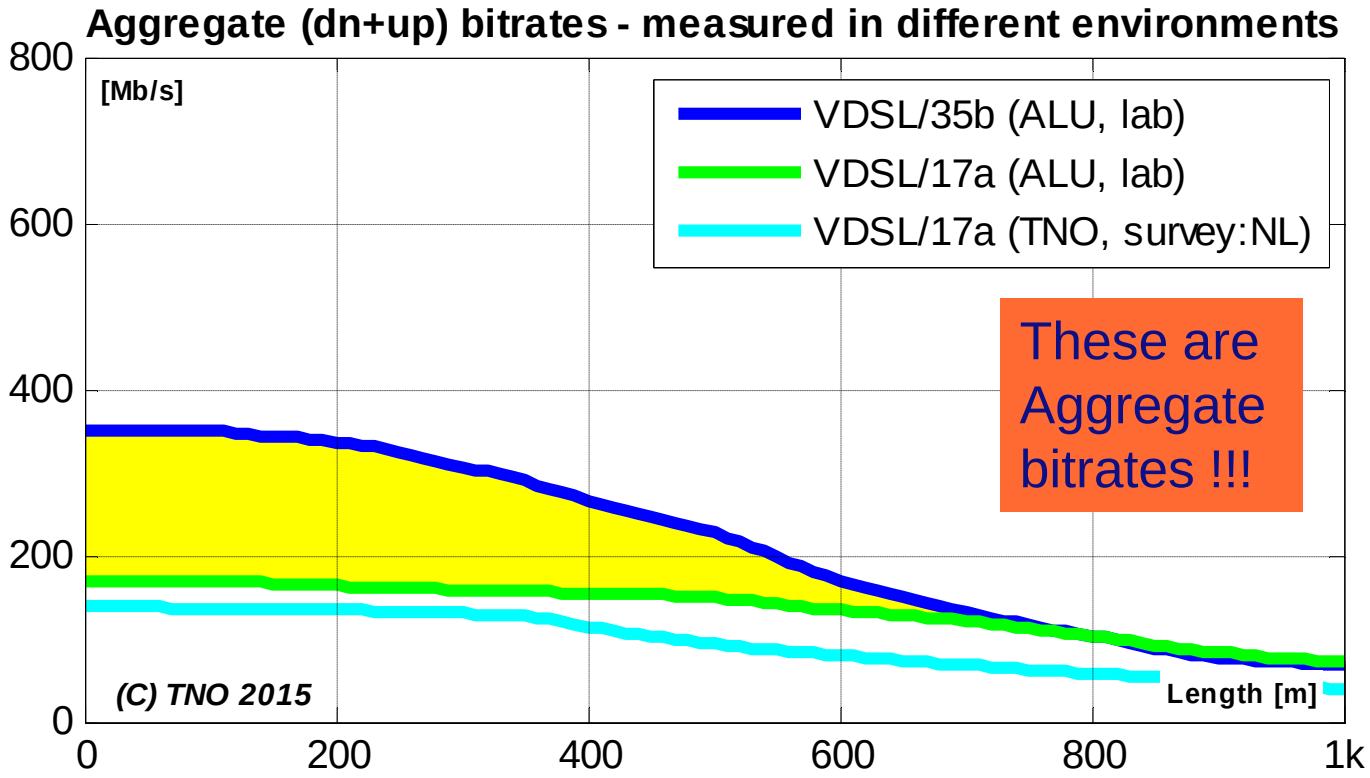
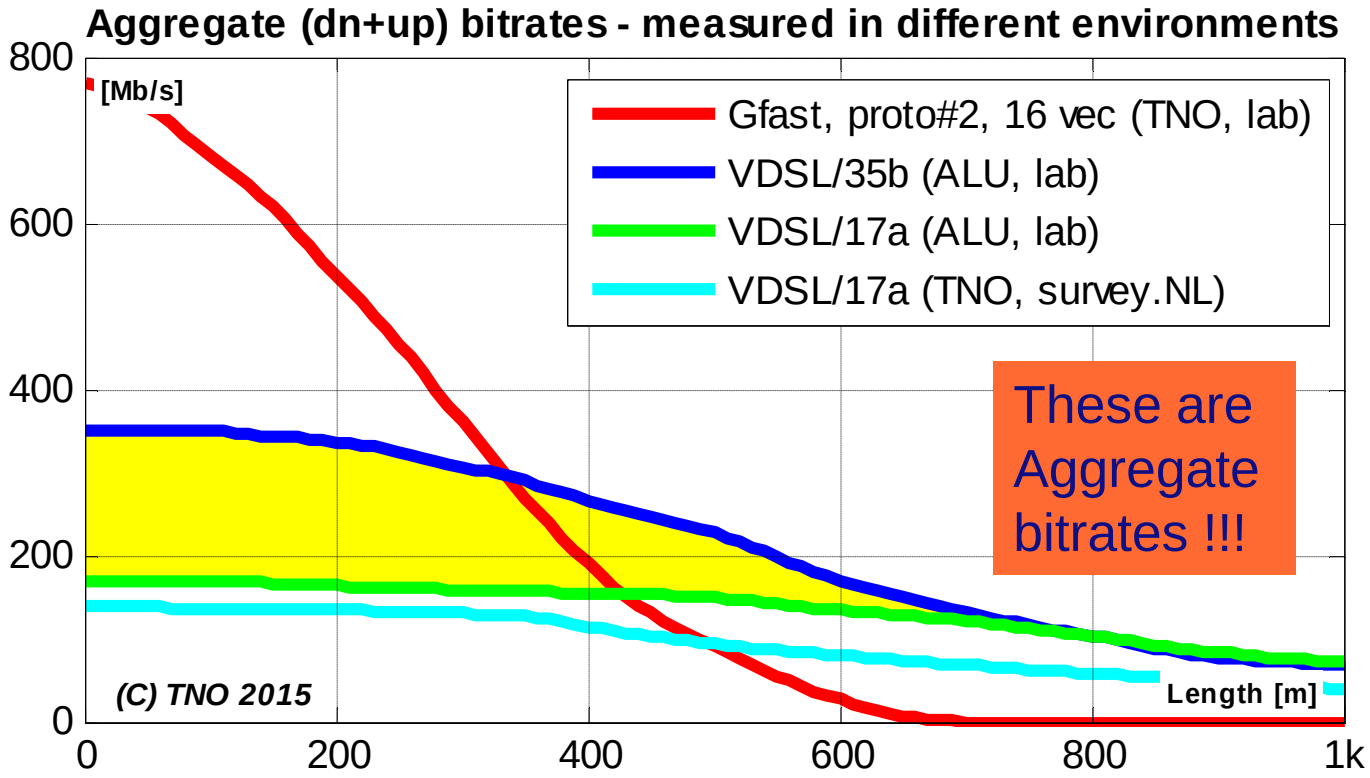


Measured bitrates for VDSL/35b

- VDSL/35b lab rates measured by ALU
- VDSL/17a lab rates measured by ALU
- VDSL/17a field rates based on 180k operational lines, variety of cables
- VDSL/17a field rates indicate how lab results may scale to field results
- Lab rates above 350m may be too optimistic compared to field rates

2. New technologies: attainable bitrates



Measured bitrates for G.fast and VDSL/35b and

- G.fast lab rates easily outperform VDSL/35b lab rates on loops up to ~350m
- VDSL/17a field rates indicate how lab results may scale to field results
- Lab rates above 350m may be too optimistic compared to field rates (G.fast & VDSL)

2. New technologies: attainable bitrates

Disclaimer

Insufficent knowledge on performance

- VDSL/35b not yet available for benchmarking @ TNO
- G.fast is still in its prototype phase (measured @ TNO)

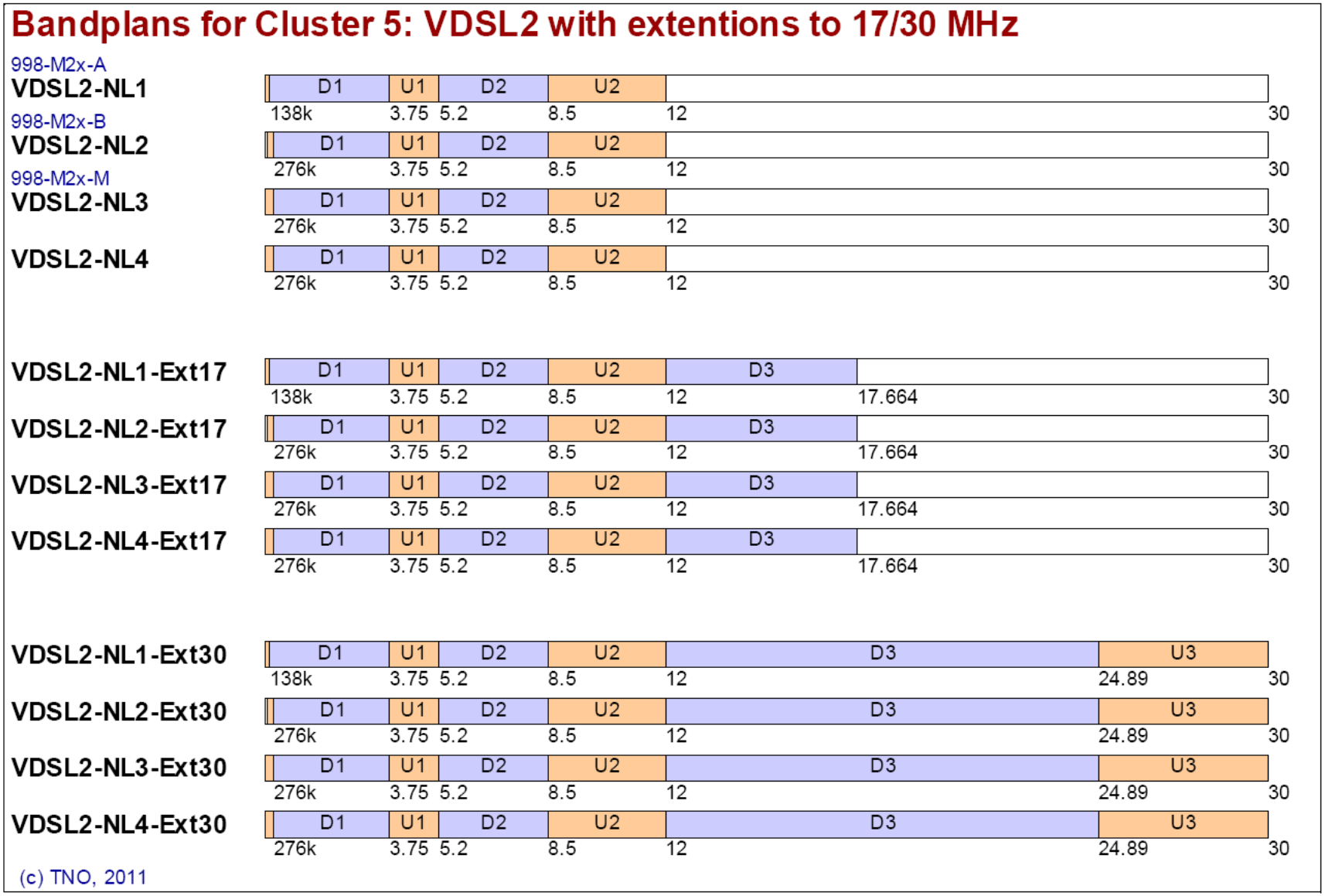
Insufficient knowledge on crosstalk coupling in the field:

- Cable characterizations in the past focussed on *lower frequencies*
- Characterizations (TNO, up to 500MHz) focussed on *new cables*
- Crosstalk increase doubles above some break frequency (*"dual slope" effect not well understood, and wire-pair dependent*)
- Paper insulated cables have higher insertion losses
- And how about "old" cables, bridge taps, … ??

2. New technologies: current status

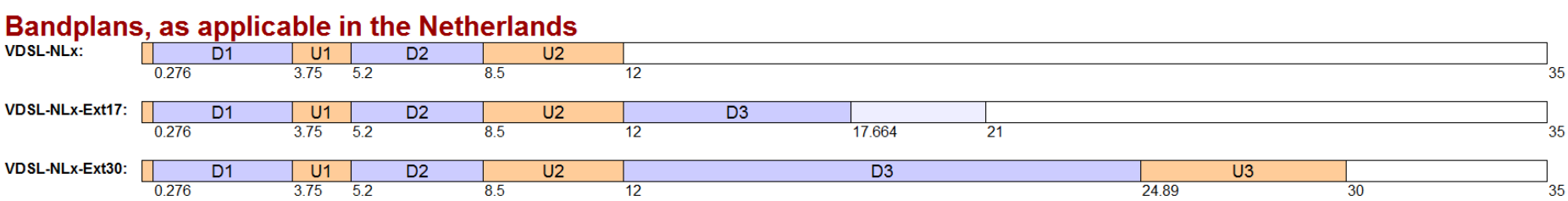
VDSL/35b	G.Fast
Amendment to ITU standard in progress Consent on “35b” expected by feb 2016	ITU standard since dec 2014
Chipset available from Broadcom. others: unknown	Chipsets available from Sckipio and Broadcom; Ikanos expected, others unknown.
Prototypes in active development by ALU; others may follow First products by Q4/2015?	Prototype systems available since Q3/2014 from various vendors (Adtran, Sckipio). Also from Huawei, ALU, …
ALU reports lab trials at a few operator labs (KPN, DT, ..)	Lab/field trials reported since Q4/2014 from many labs (TNO, BT, Orange, Telefonica, TDC, Swisscom,…)
• Some operators expressed strong interest in VDSL/35b (KPN, DT) • Others keep a *dual-technology strategy* as an option	• BT: large scale field trials by summer 2015 • Swisscom: “after 2016 with G.fast”, • Proximus(Belgacom): “G.fast=preferred” • explicit interest from many others (AT&T, Orange, ..)

3. Spectral impact on legacy: about VDSL/35b



3. Spectral impact on legacy: about VDSL/35b

Spectral compatibility should be maintained



Bandplans up to 30MHz agreed for the Netherlands, some years ago

- VDSL/17a deployed – out of band signals up to 21 MHz
- VDSL/30a is allowed but not deployed in NL

We need something for VDSL/35b. different options:

- Stop at 30MHz, keeps everything as it was before
- Add something above 30MHz
- Change between 17 and 30MHz as well

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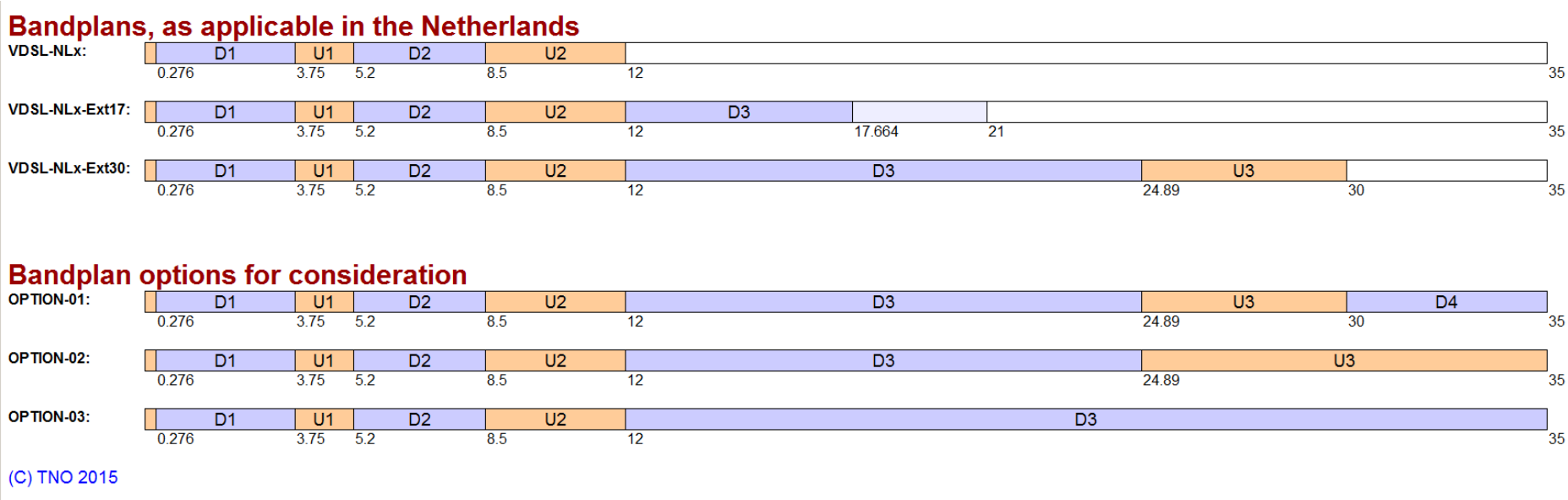

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ITU standardization tends to “option-03” ***alone***

3. Spectral impact on legacy: about VDSL/35b

Pros and Cons of different VDSL/35b bandplans

Ratio between up & downstream birates (*business consideration*)

- Opt-01: Both US and DS will improve (*compared to VDSL/17a*)
- Opt-02: US improves more and DS improve less (*compared to opt-01*)
- Opt-03: Only DS will improve (*compared to VDSL/17a*)
- Once a bandplan is chosen, this new US/DS ratio is fixed !! (*unless you change the bandplan afterwards*)

ITU tends to "DS-only" bandplan (*option-03*) :

- This choice simplifies upstream hardware
- Additional UPBO requirements not needed (upstream Power Back-off)
- Requires to change the current 30MHz bandplans for the Netherlands
- Makes US/DS ratio more asymmetric

Use of spectra above 17MHz will restrict the use of other technologies in the same cable (*like G.fast*)

3. Spectral impact on legacy: about G.fast

How to deploy G.fast without negative impact on legacy?

Option A: Only together with HDSL/ADSL/SDSL in same cable

- G.fast transmits only between 2MHz and 106MHz (in future 212 MHz)
- This protects everything below 2MHz
- This option offers the highest performance for G.fast

Option B: G.fast also together with VDSL in same cable

- *>17MHz*: can work, but not convenient due to bitrate penalty,
- *>35MHz*: can work, but discouraged due to significant bitrate penalty

Conclusions / recommendations

Discussed options for next generation bitrates in copper

Still plenty of copper capacity, new technologies are soon available

- VDSL/35b and G.fast are coming, both in prototype phase
- Each technology has its own pros an cons
- Choice not obvious, probably a roadmap: *function(place, time)*
- Gb/s domain within reach (*copper has still cost advantage over full FTTH*)

Both technologies have SpM issues, and can be solved for both

- Broader spectrum requires new/updated bandplans
- VDSL/35b easy to deploy, but performs on short loops at lower bitrates then G.fast
- G.fast and VDSL in the *same* cable gives significant bitrate penalty for G.fast (*with VDSL/17b is an option but with VDSL/35b is to be discouraged*)

Recommendation: Identify your position on:

- What bitrate is needed at what location and from what date at what costs
- Which technology roadmap meets your requirements the best
- If VDSL/35b then define a bandplan according to required US/DS ratio
- If also G.fast then identify how to handle the SpM complications with legacy

VDSL/35b and G.fast enable the next generations in broadband


TNO