Supervectoring VDSL & G.FAST

Delivering High Bandwidth Service Over Existing Copper Assets

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Outline

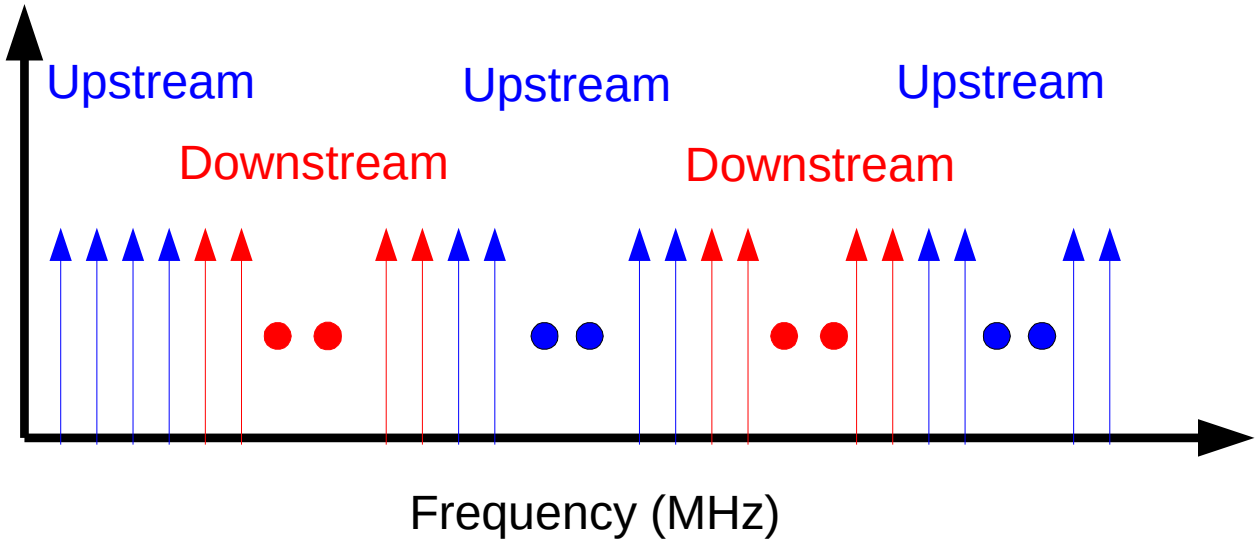
- “Supervectoring” G.993.2 Amd 1, Annex Q (11/2015)
- G.FAST Overview
- Comparison of the technologies
- Broadband Forum – UNH G.FAST Interop Status

G.993.2 Annex Q (11/15)

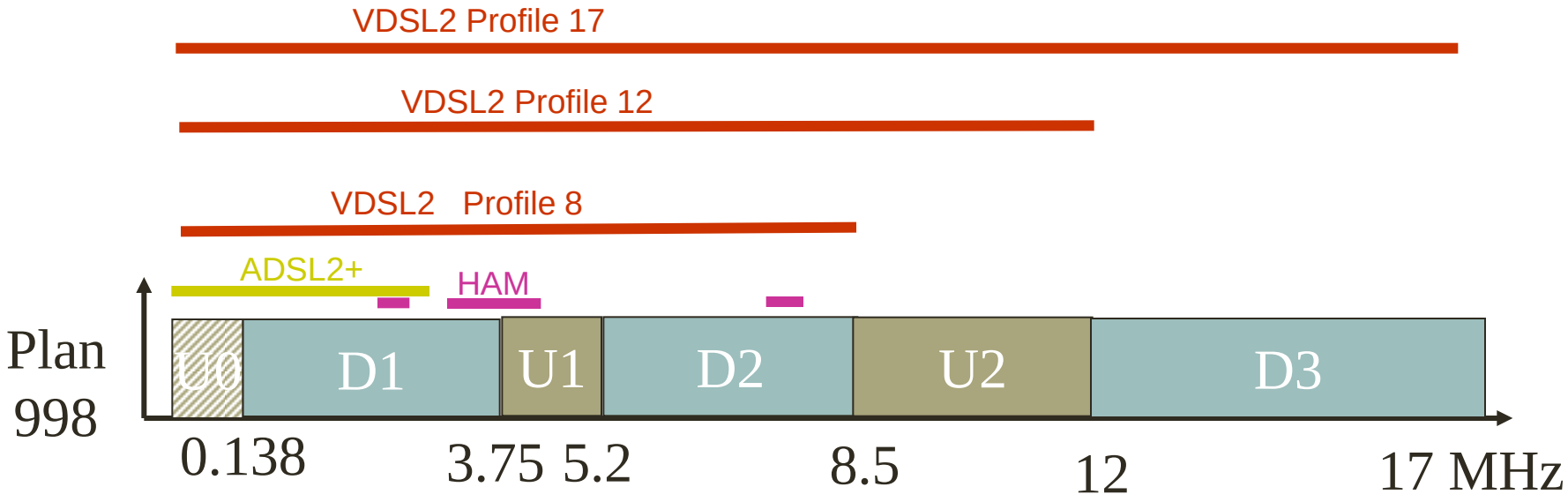
“Supervectoring”

VDSL2 Fundamentals - Discrete Multi-Tone

- DMT Line Code Is Made Up of Individual Sinusoidal Carriers Whose Amplitude and Phase Change to Signal the Data Bits
- The VDSL2 (G.993.2) Has Tone Spacing of 4.3125 kHz
  - >4000 tones for profile 17
  - >8000 tones for profile 35b (New ITU VDSL Amendment Annex Q)
- The Upstream Spectrum is Separated From Downstream. This Type of Segregation is Frequency Division Duplexing (FDD)

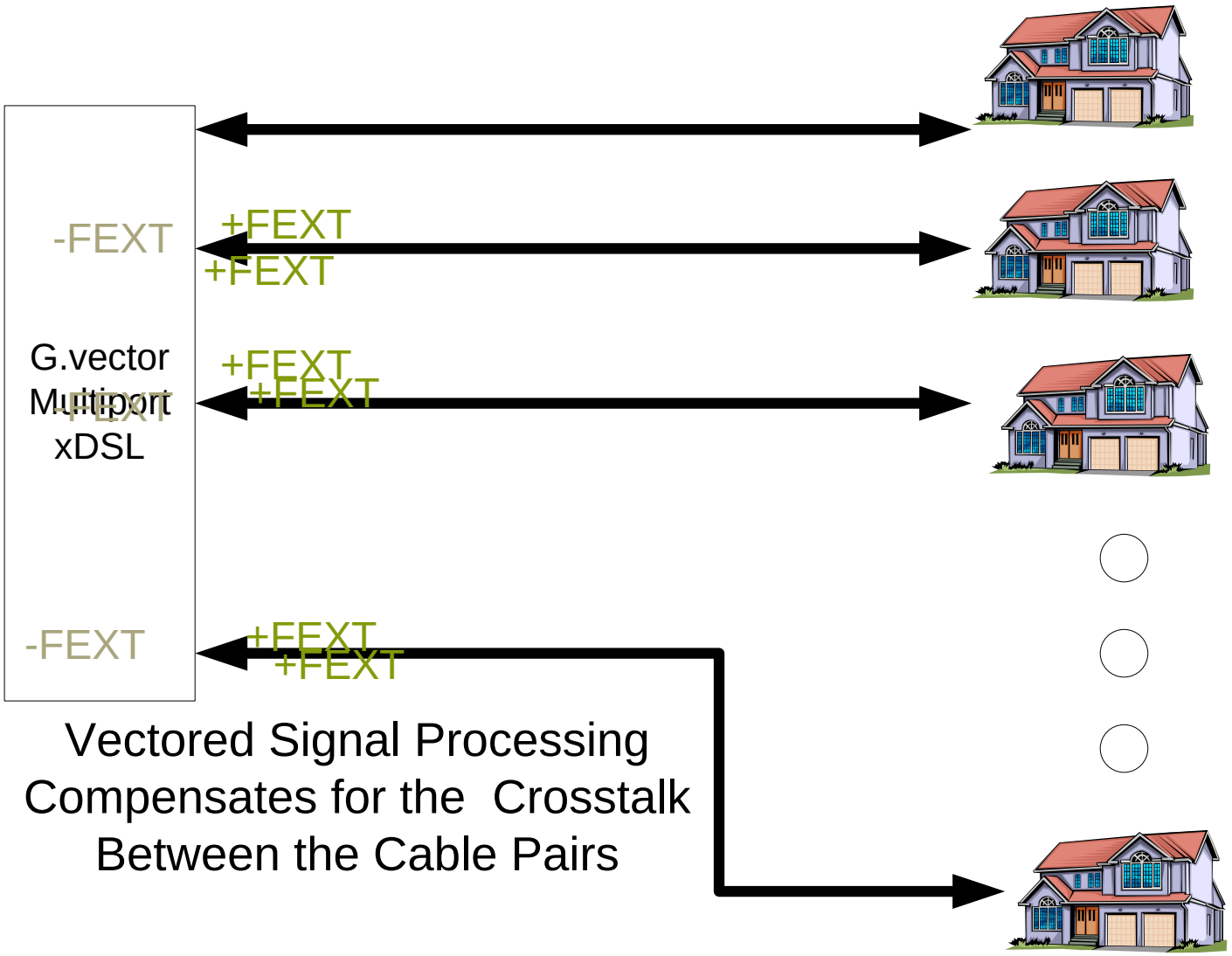


Profiles & Band Plan 998

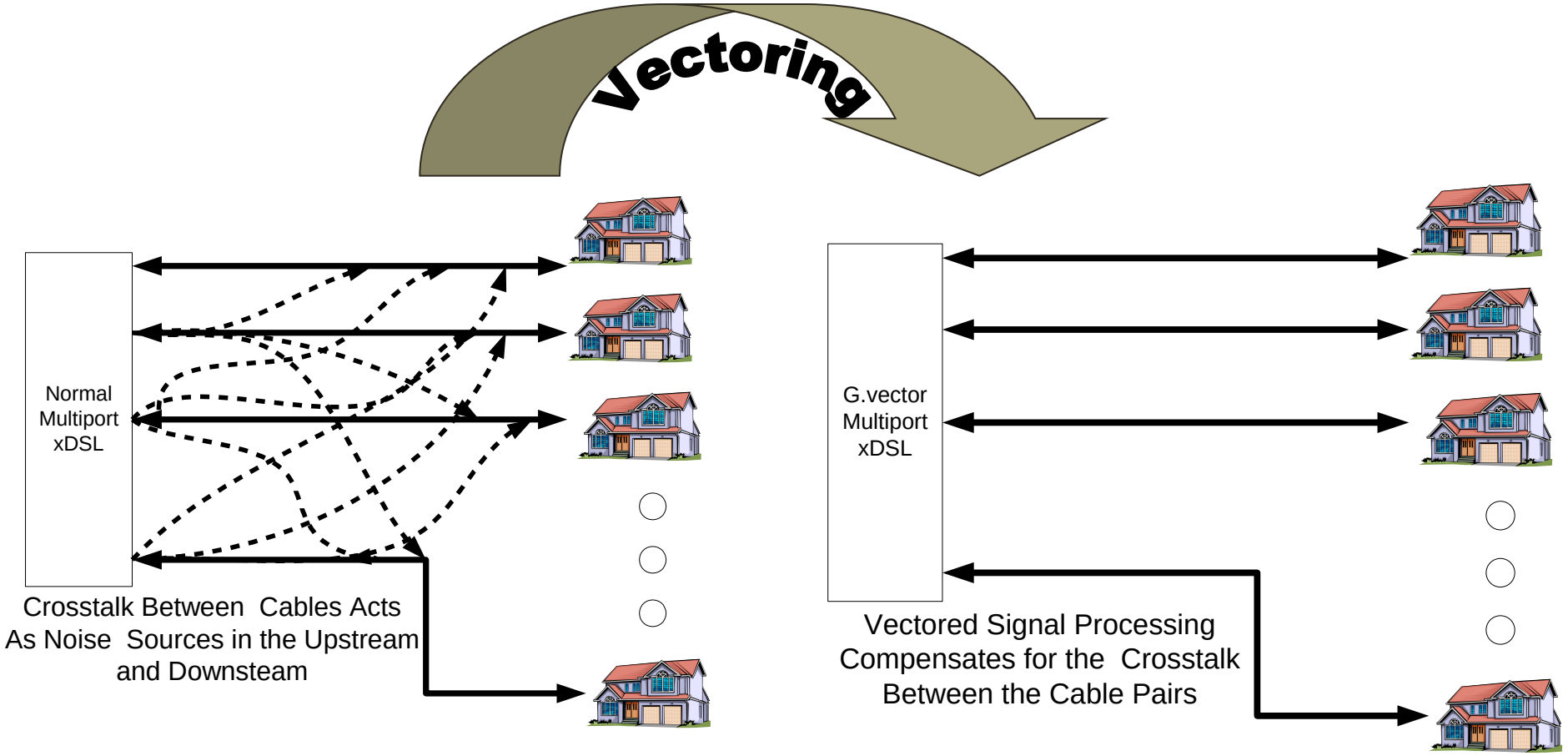


- D3 usable out to 2000 ft 26 AWG
- U2 usable out to 2500 ft 26 AWG
- D2 usable out to 3500 ft 26 AWG
- U1 usable out to 4000 ft 26 AWG
- HAM Bands: 1.81-2 Mhz, 3.5-4 MHz, 7-7.3 MHz

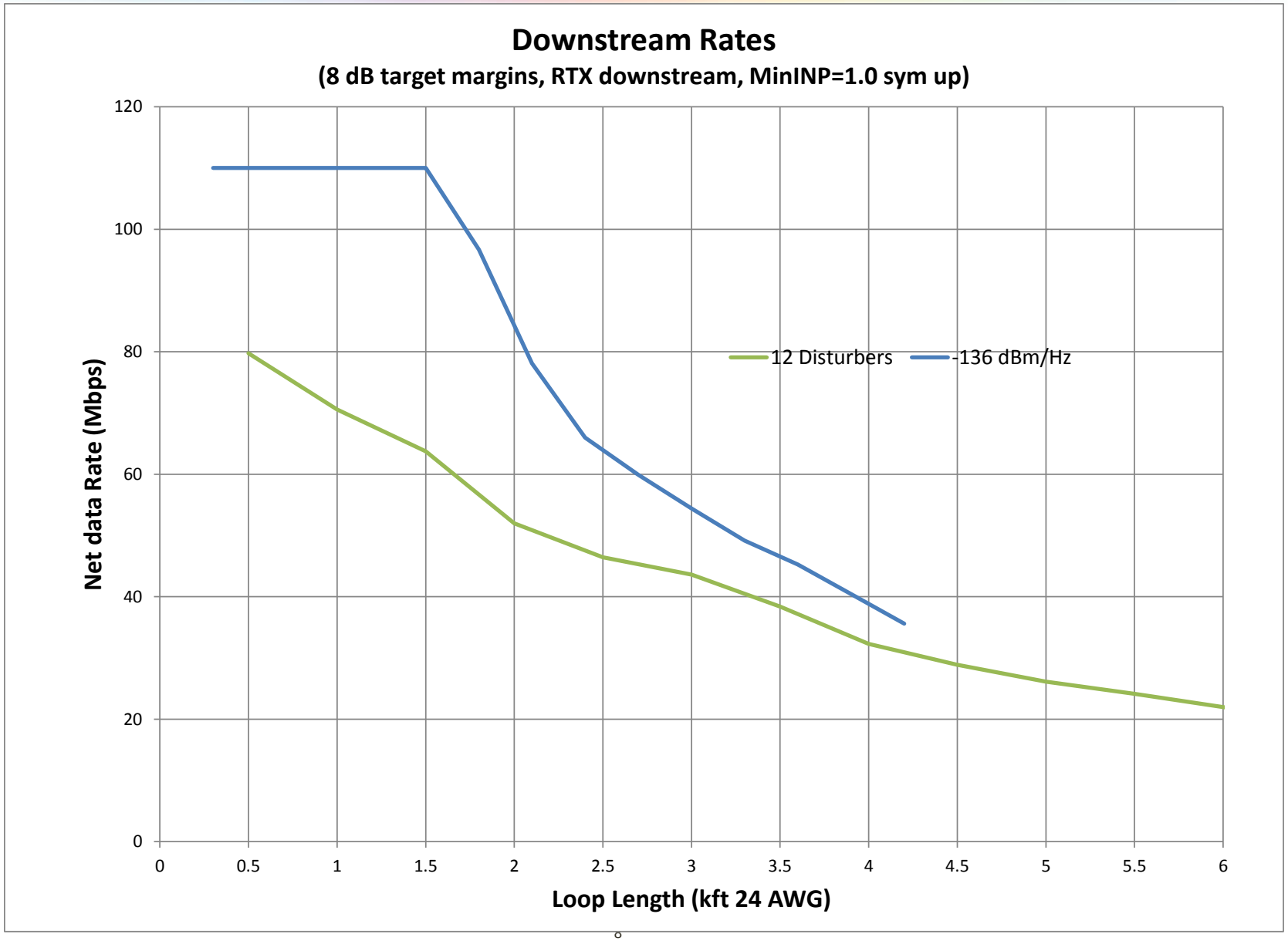
What is Vectoring?



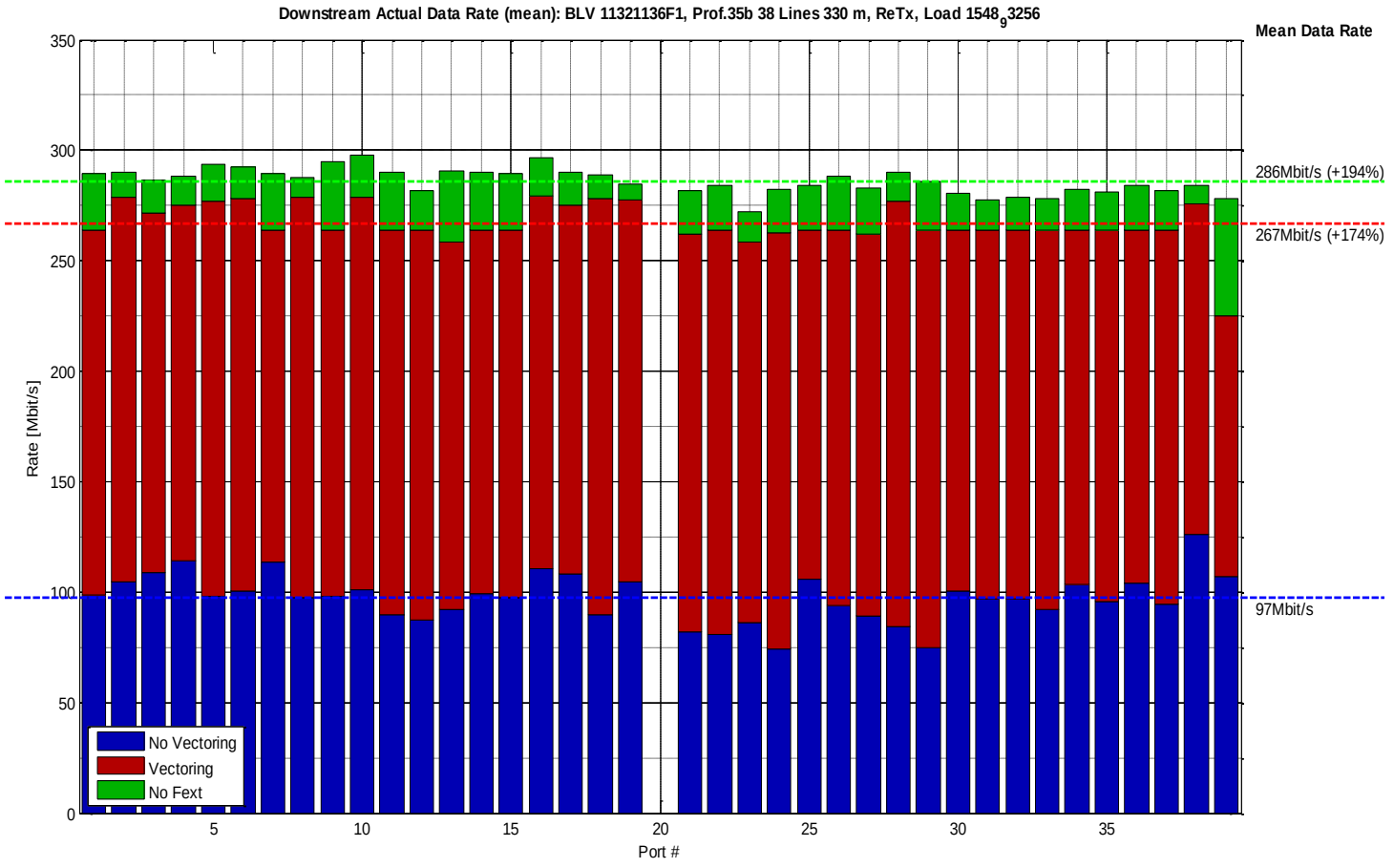
G.Vector ITU Recommendation October 2009



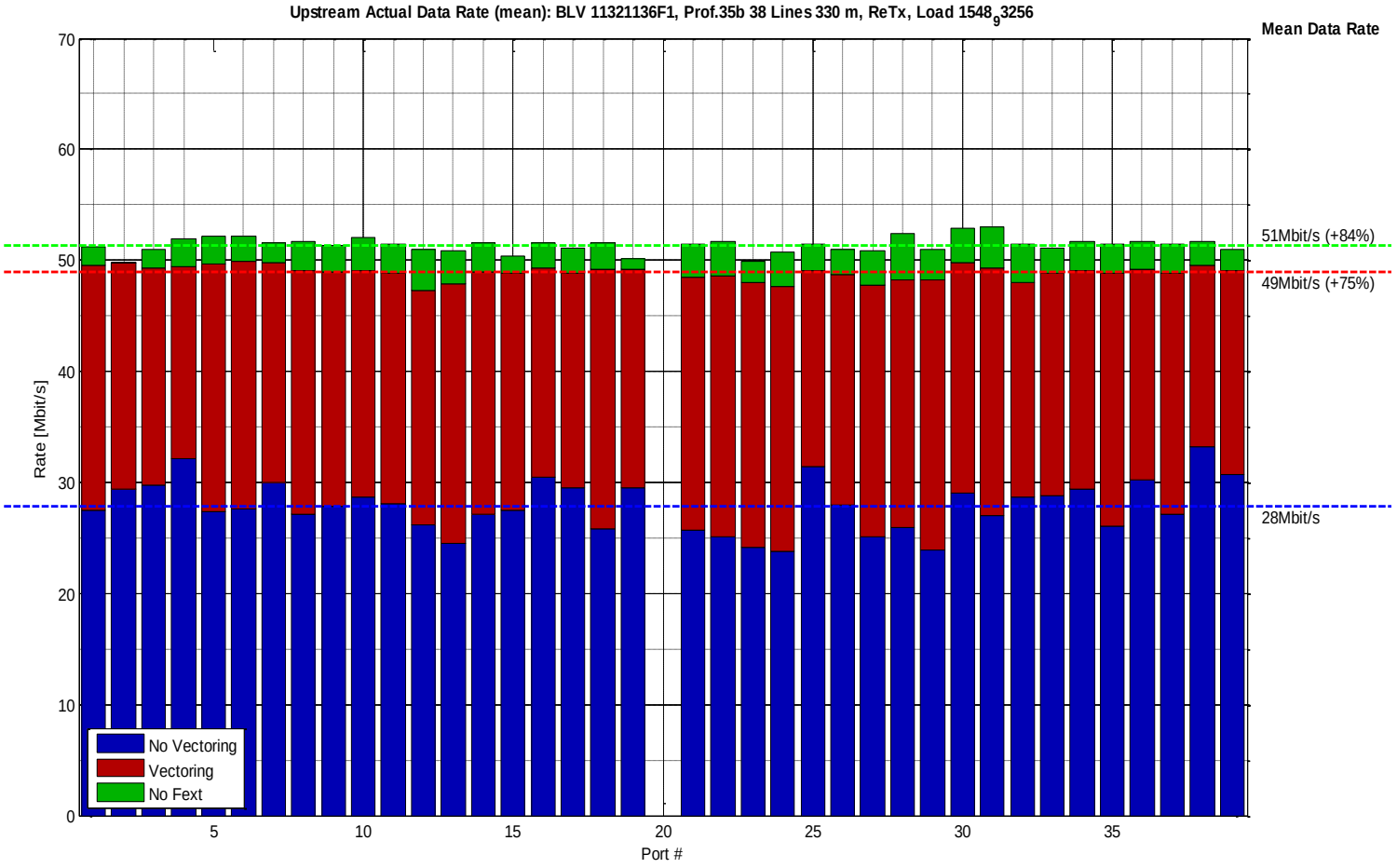
VDSL2 Prof 17 Vectoring Performance



Measured Supervectoring (35b)



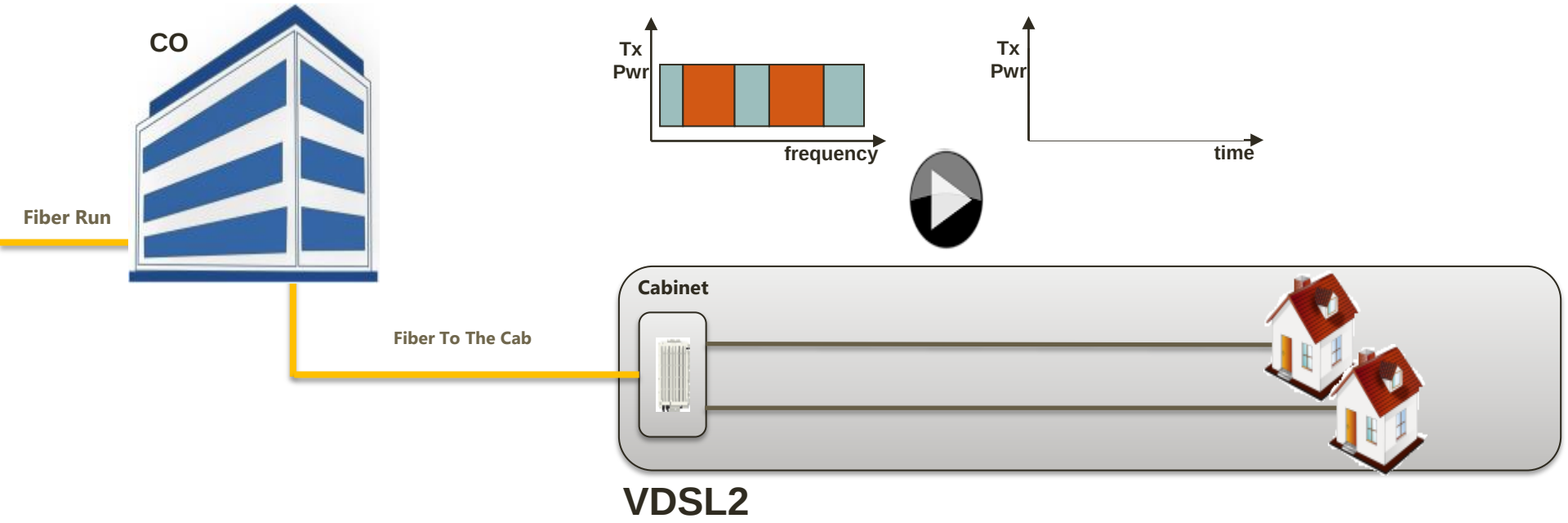
Measured Supervectoring (35b) Up



G.FAST Overview

G.Fast – Operational Considerations

- ADSL/VDSL use Frequency Division Duplexing to divide US and DS bandwidth

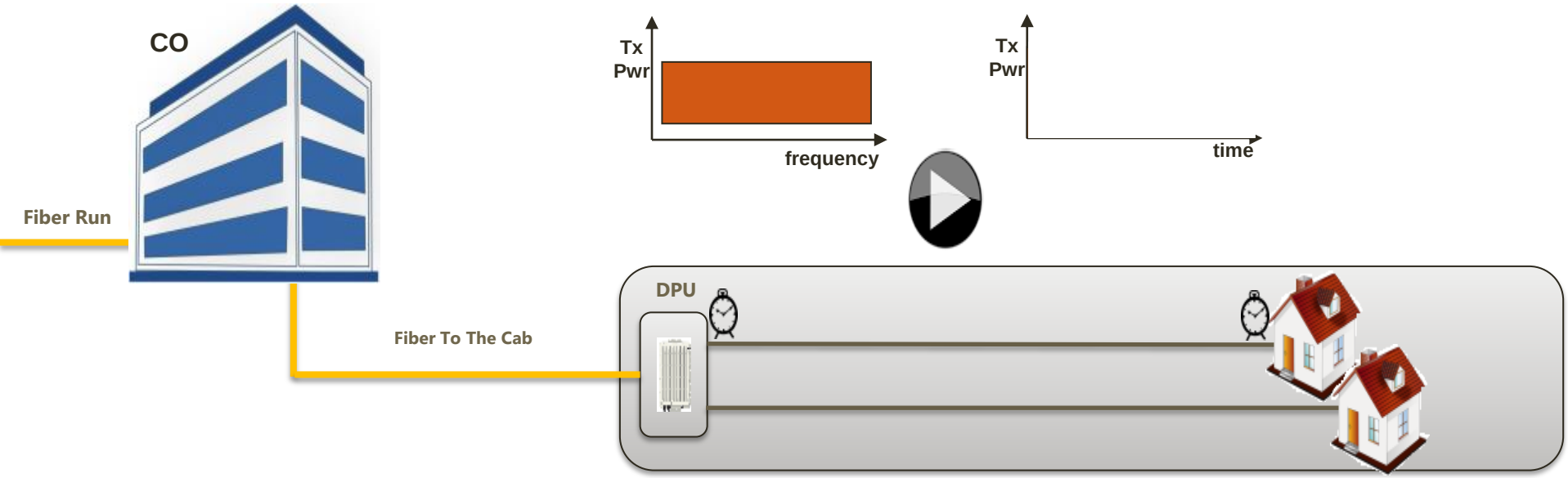


Separated frequencies in use for upstream/downstream throughout transmission

Full Duplex – transmits and receives at the same time

G.Fast – Operational Considerations

- G.Fast uses Time Division Duplexing to divide US and DS bandwidth



- What does this mean?

G.FAST

Entire spectrum is used for upstream and downstream directions – but NOT simultaneously. Half Duplex – Time Based.

Configurable services, asymmetric or symmetric based on the time ratio used. (Even high US / Low DS profiles).

NOTE: All ports in a Vectored bundle MUST use the same profile to avoid NEXT (Near End Cross Talk)

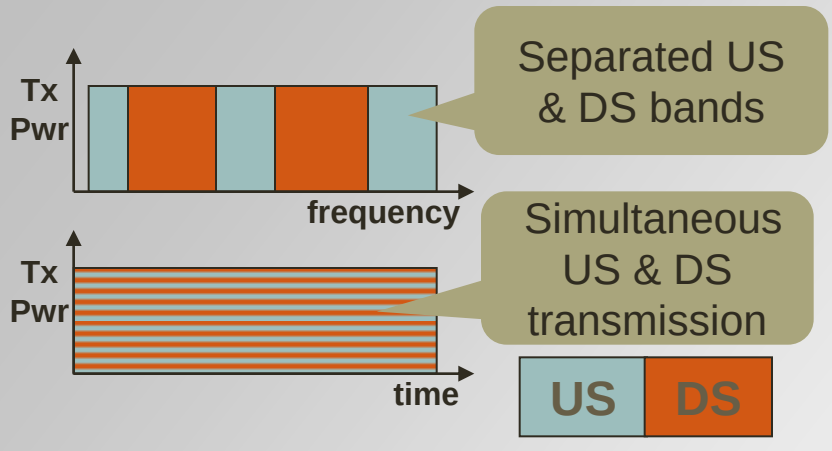
Coax installs are non vectored – each port can operate at different US/DS Ratios

Using TDD as a Duplexing Scheme

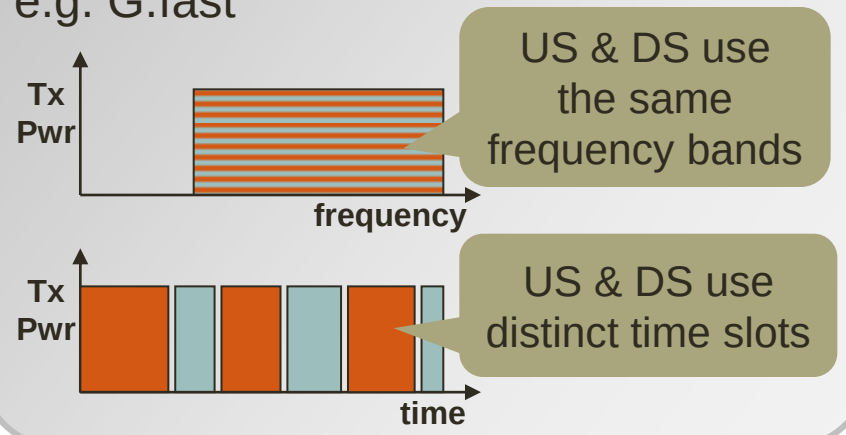
- ⊕ Simple transmitter and receiver (only one FFT)
- ⊕ No need for a hybrid (not transmitting when receiving)
- ⊕ Power efficient (transmitter/receiver shutdown when not used)
- ⊕ Flexible US/DS data rate asymmetry (no bandplans)

- ⊖ Synchronization of all transmitters required
- ⊖ Guard time between downstream and upstream required
- ⊖ Larger round trip time
- ⊖ Requirement to buffer data
- ⊖ No spectrum compatibility with ADSL/VDSL

Frequency Division Duplex (FDD)
e.g. ADSL2/2plus, VDSL2

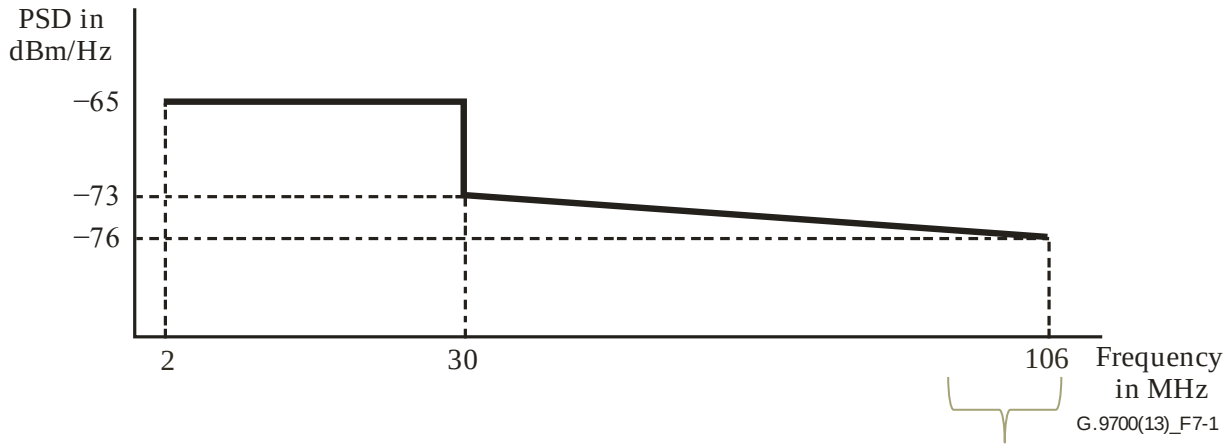


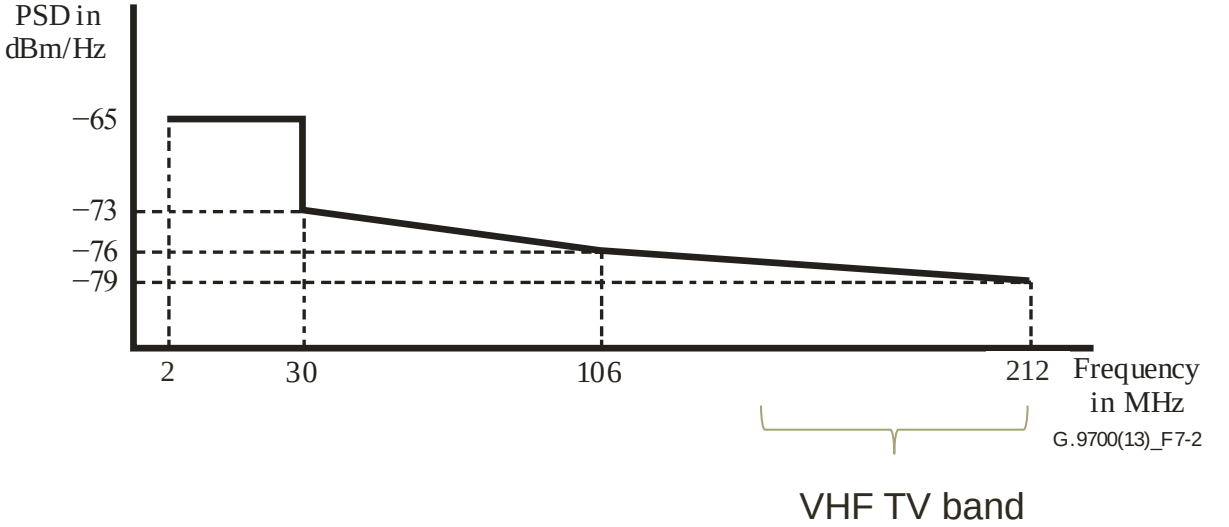
Time Division Duplex (TDD)
e.g. G.fast



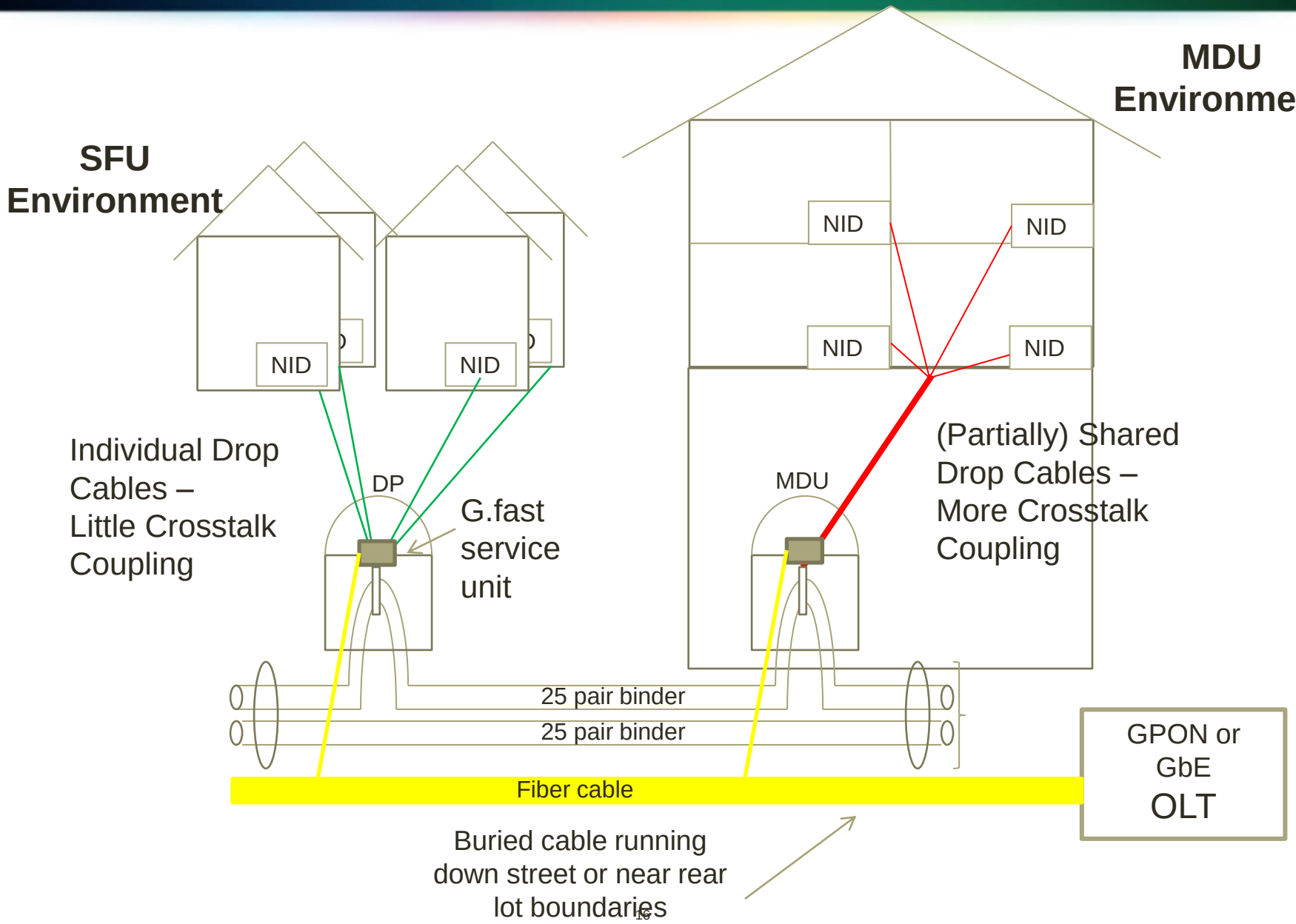
G.fast Profiles & Limit PSD (G.9700)

- G.9700 contains the limit mask definitions for two profiles
  - 106 MHz
  - 212 MHz
- Current transceiver specification (G.9701) only defines the 106 MHz profile
- Max aggregate transmit power is 4 dBm for 106 MHz profile

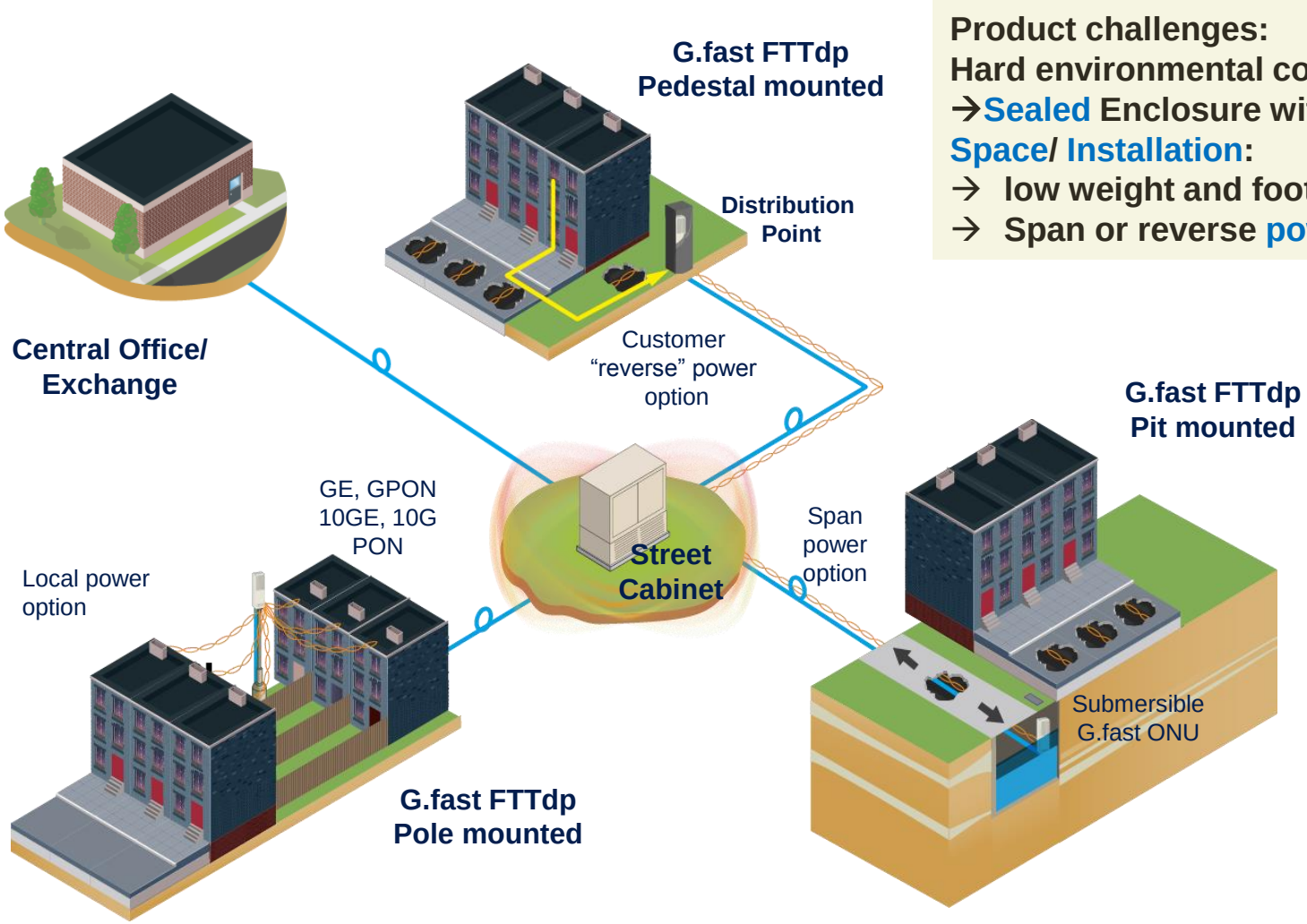




FTTdp Deployment Models (US)



FTTdp variants: Pedestal, Pit, Pole



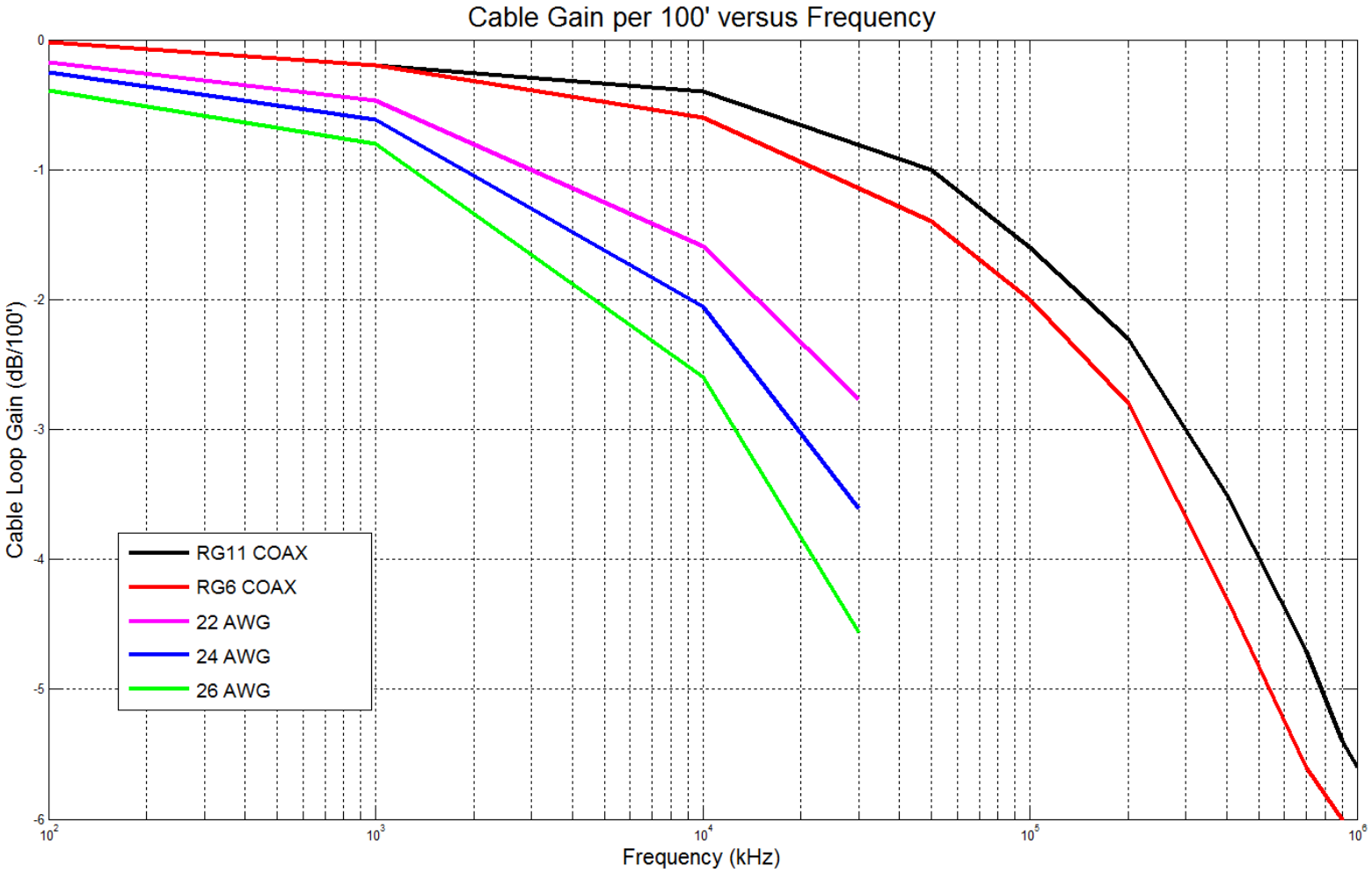
Product challenges:
Hard environmental conditions:
→Sealed Enclosure with passive cooling
Space/ Installation:
- **→ low weight and footprint**
- **→ Span or reverse powering options**

G.FAST vs VDSL Supervectoring

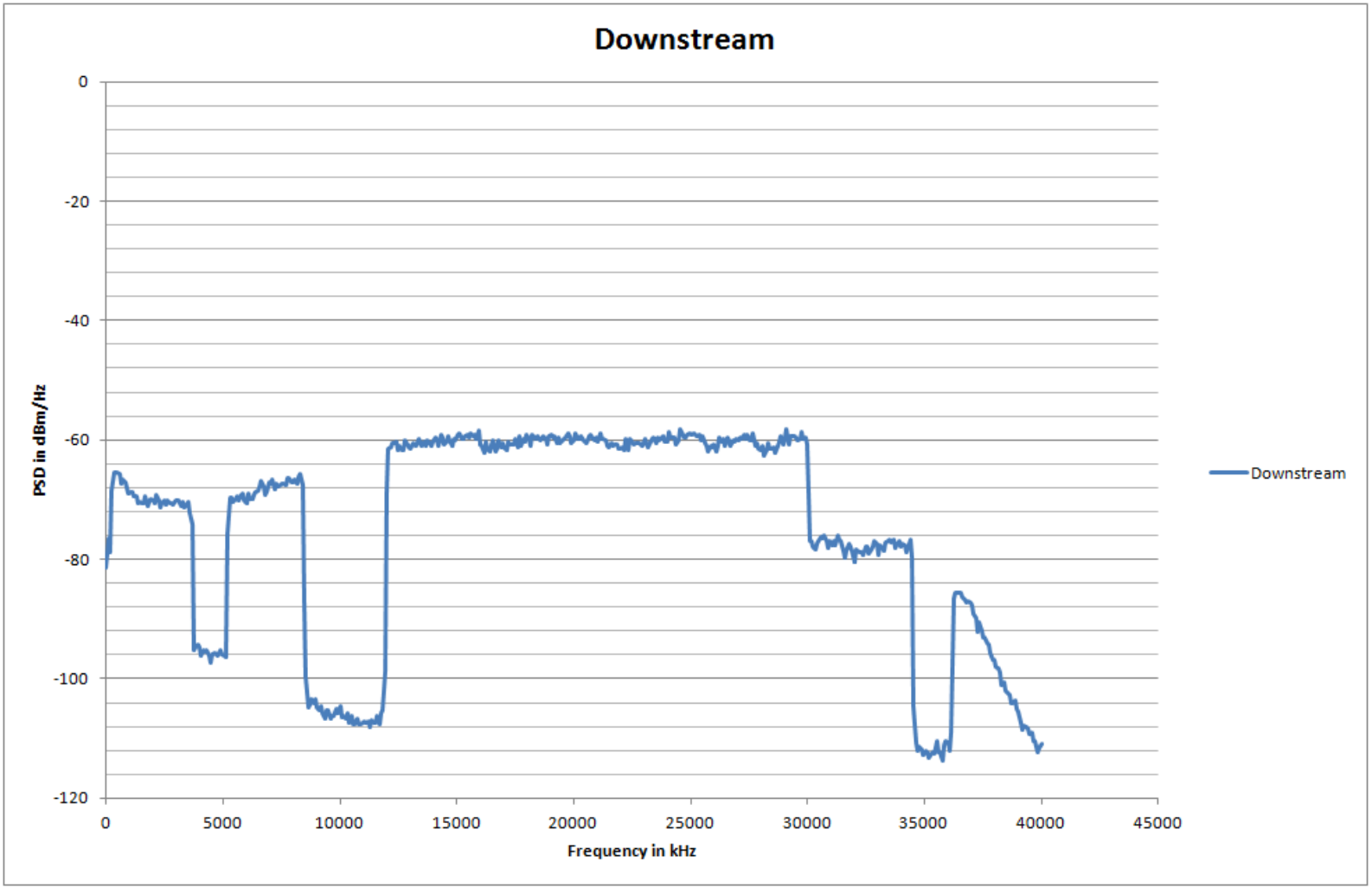
Why FTTdp or FTT deep Node

- Deploy fiber as deep into neighborhood as is economically feasible
- Then use existing copper assets for the last several hundred feet to the house or apartment
- Allows faster time to market with higher service rates
- Supports longer term FTTH strategies by deferring the full costs until the bandwidth demand exceeds what is achievable from the DP copper assets
- Incrementally overcomes the physics of the copper plant faster = shorter

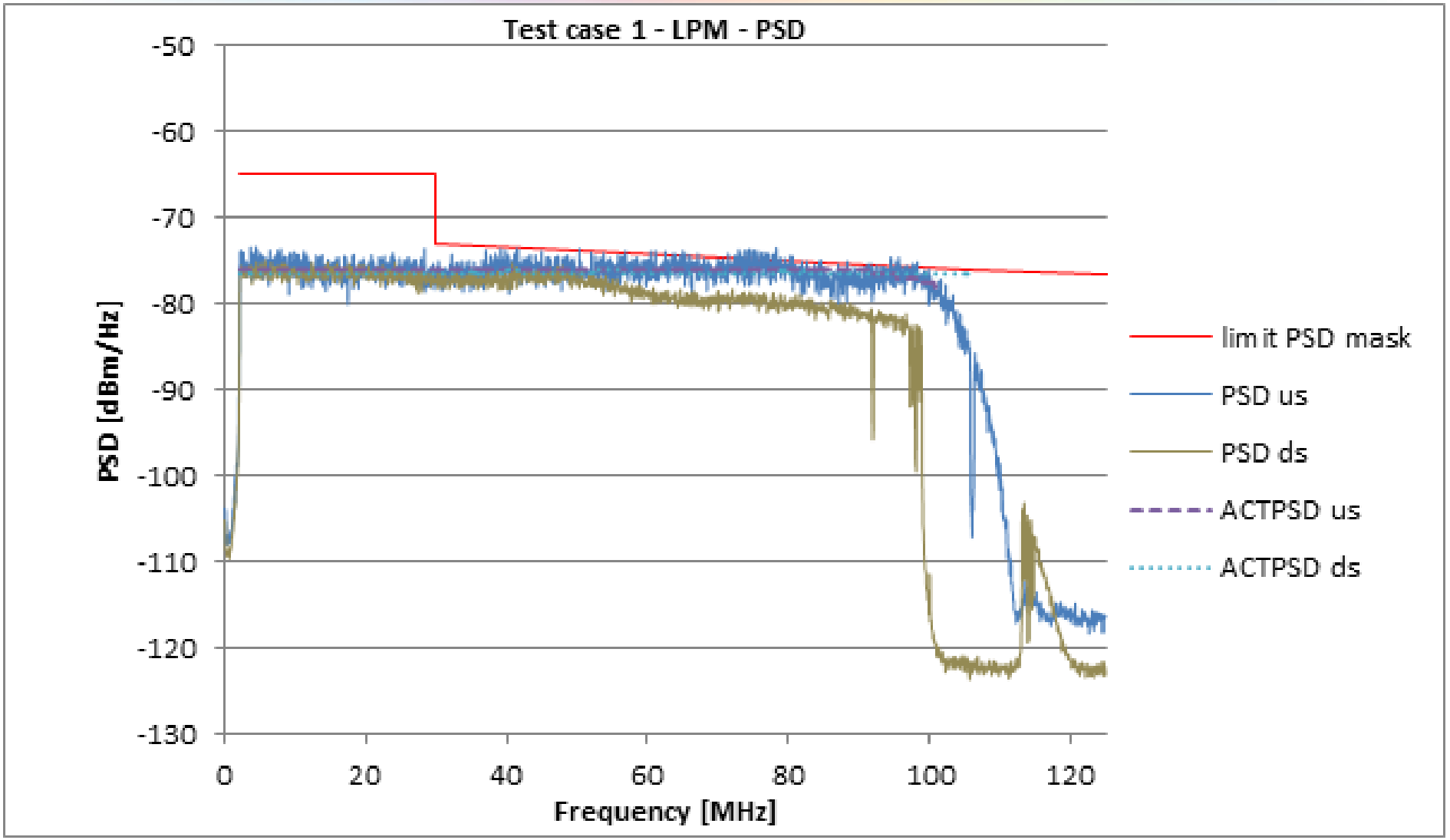
Cable Loss Characteristics



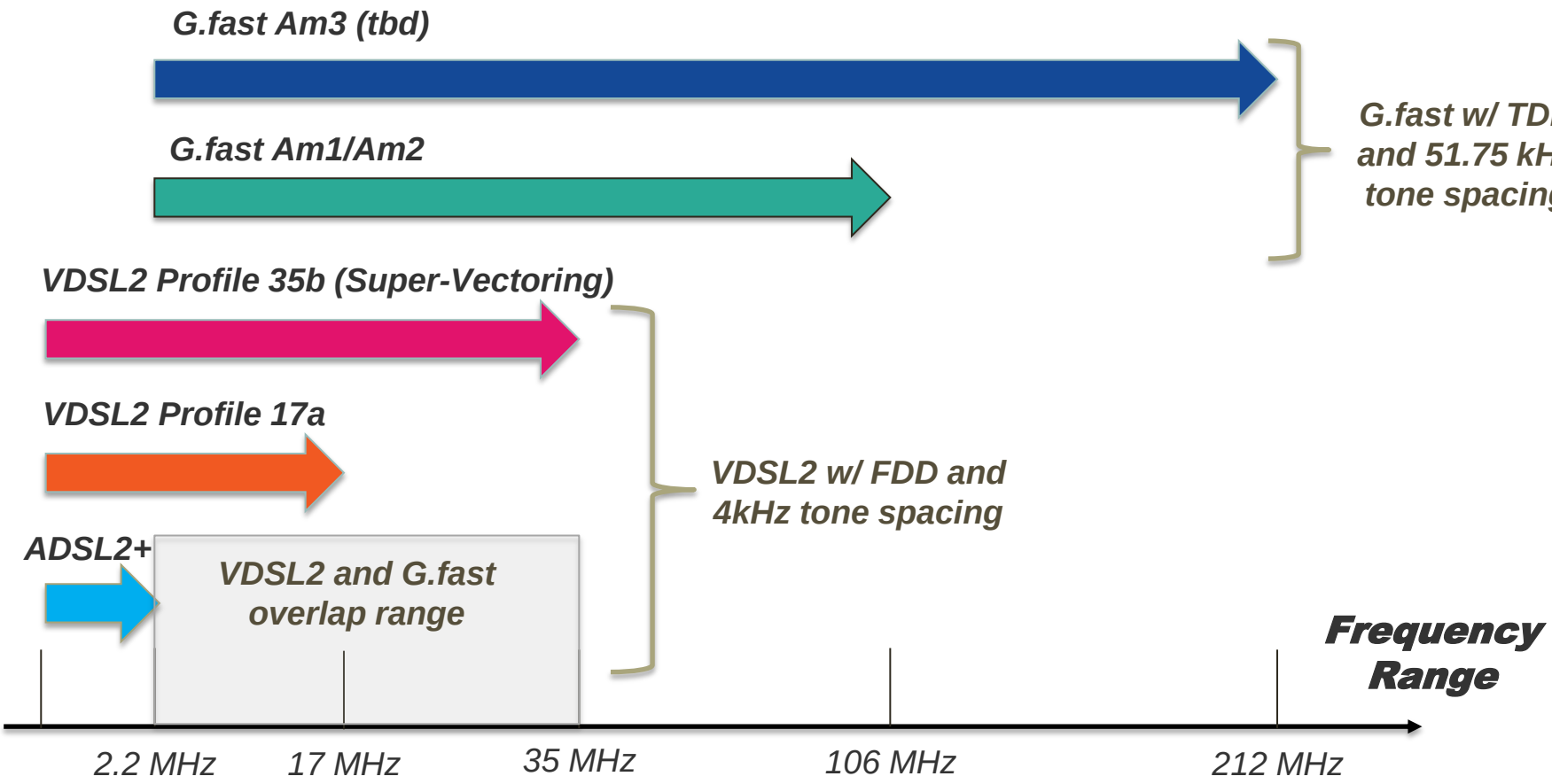
Actual 35b Supervectoring PSD



Actual 106 MHz G.FAST PSD

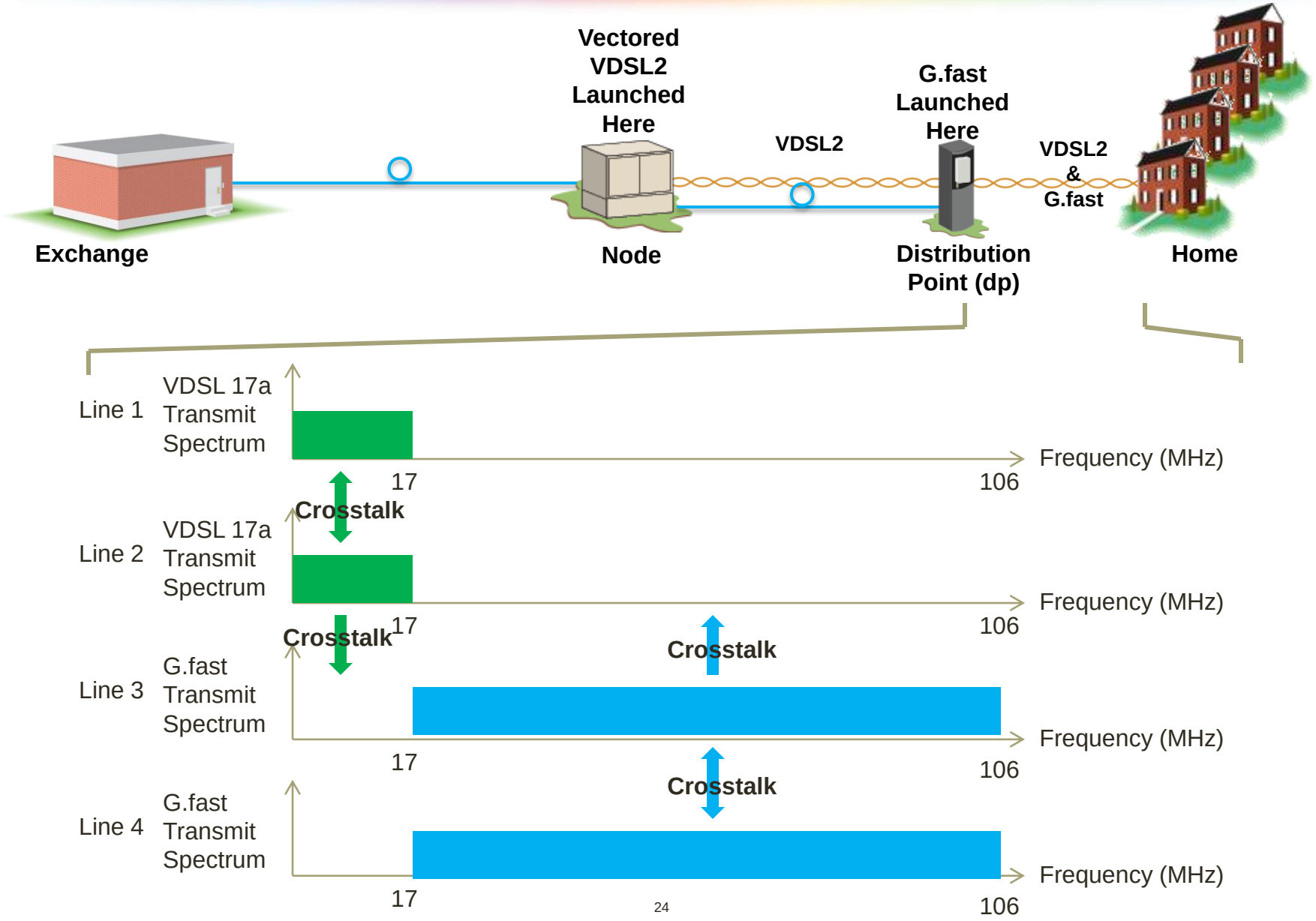


Copper Access Technologies

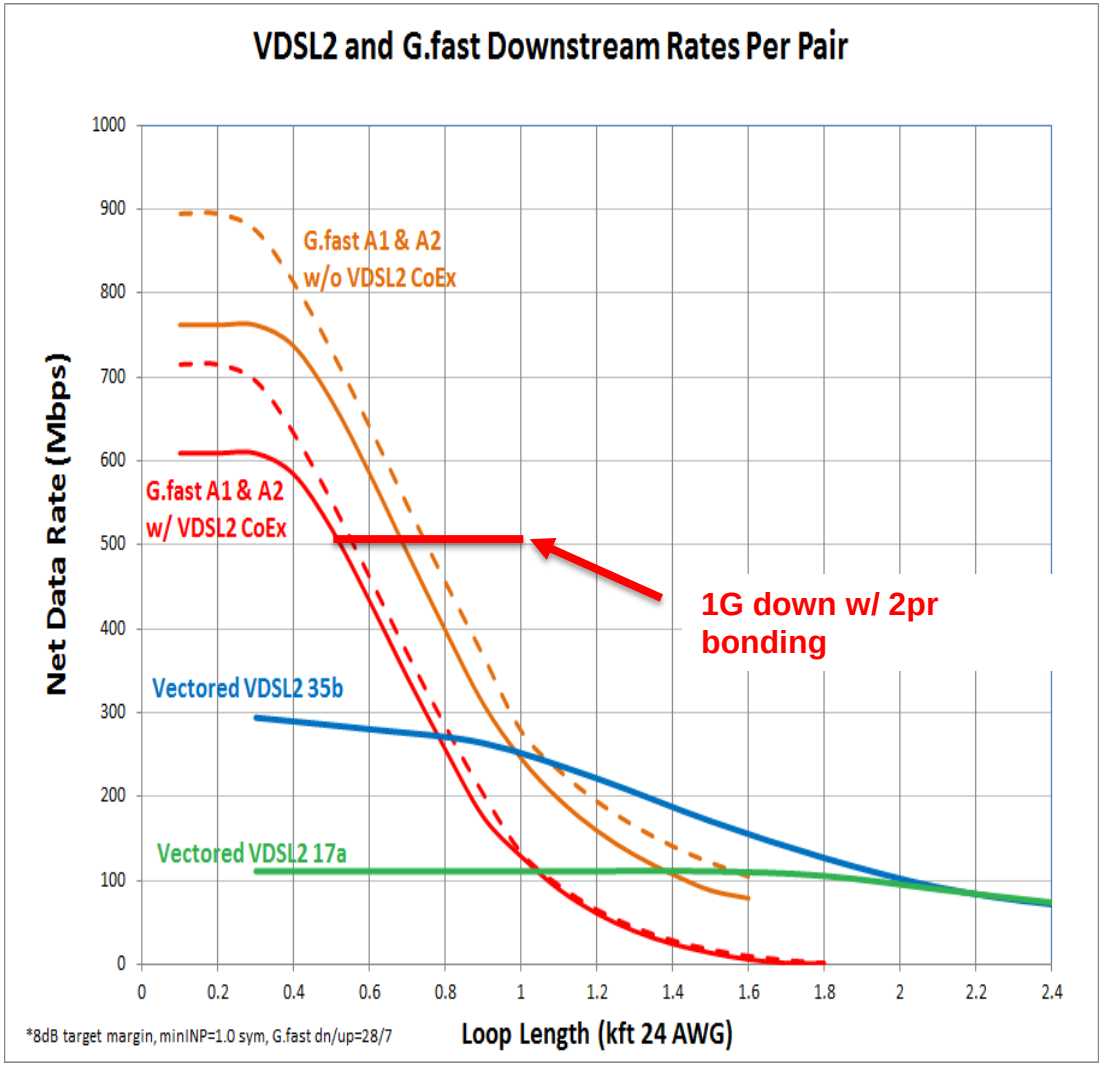


Co-existence is a key consideration for VDSL2 and G.fast

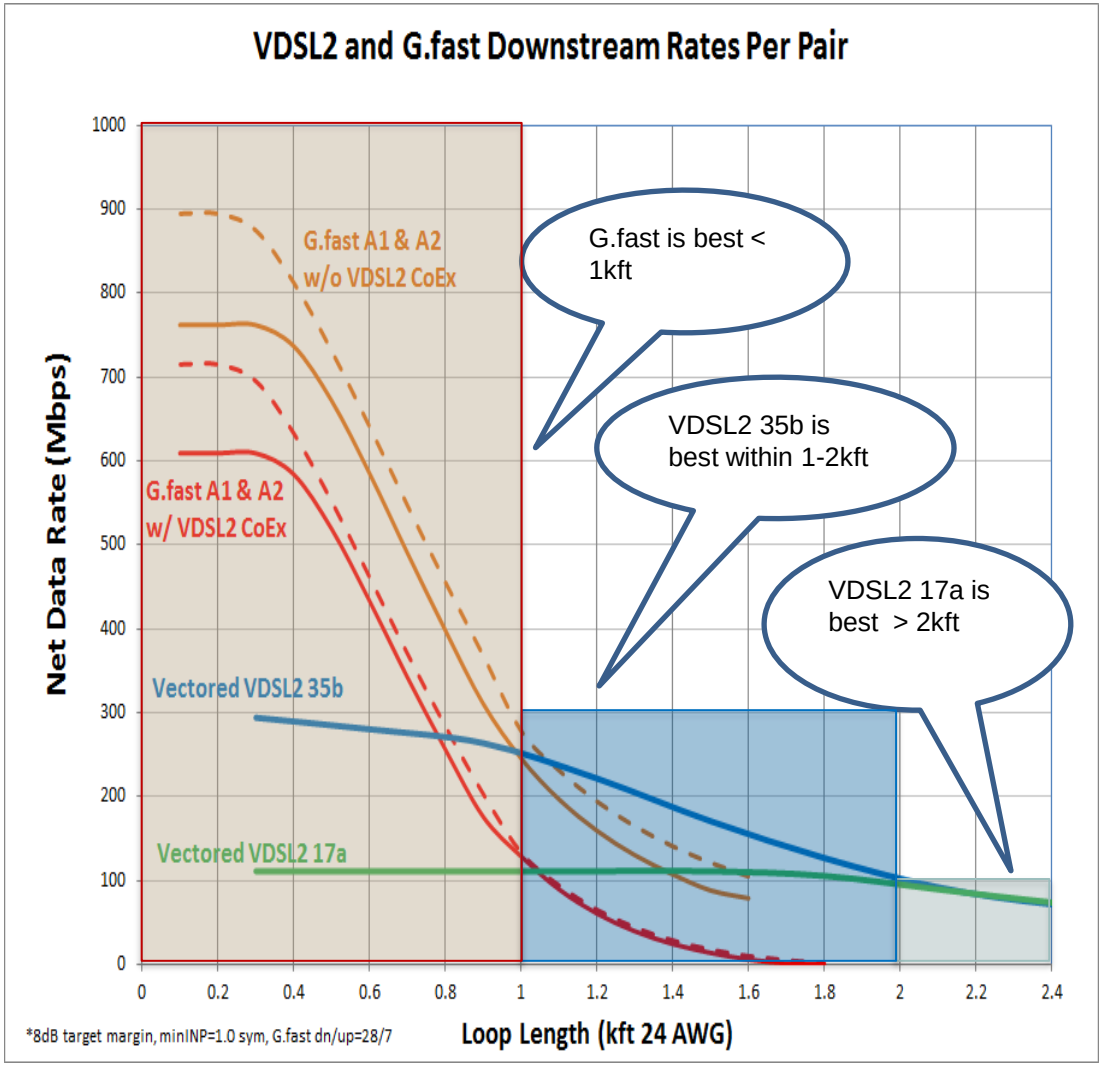
Spectral Compatibility



VDSL2, Super-Vectoring and G.fast



VDSL2, Super-Vectoring and G.fast



Very high rates, very short loops

- The G.fast standard outlines these rate/reach targets:
  - Gigabit @ <300 ft
  - 500Mbps @ 300 ft
  - 200Mbps @ 650 ft
  - 150Mbps @ 800 ft
- VDSL2 (17a) with vectoring:
  - 110Mbps @ 1500 ft
- VDSL2 (35b) with vectoring:
  - 250 Mbps @ 1000 ft

Under 300 ft and vectoring required for Gigabit

BBF University of New Hampshire G.FAST Interop Status

List of UNH G.FAST Interop Test Objectives

- Chipset Level Initialization
  - G.hs (handshake) & Mode Selection
  - Establish Downstream Special Operations Channel (SOC)
  - Complete Initialization of Channel Discovery Phase
  - Complete Channel Analysis and Exchange Initialization
- Showtime
  - Single Line Initialization
  - Inventory Data Test
  - Vectoring
    - Co-located
    - Non-Co-located
  - Disorderly Shutdown and Activation of a Line in a Vectored Group
    - Co-Located
    - Non-Co-Located
  - G.9701 Test Modes (began in January 16)
  - Sub-carrier Masking (began in January 16)
  - Throughput Test (began in January 16)

List of UNH G.FAST Interop Test Dates

- UNH G.FAST Interop Testing
  - Jan 26-30, 2015
  - Mar 9-13, 2015
  - June 1-5, 2015
  - July 27-31 2015
  - Sept 8-12, 2015
  - Nov 2-6, 2015
  - Jan 25-29, 2016

Recent New Testing Results

	Pass	Fail	Not Tested	Not Supported
G.9701 Test Modes	5	2	45	1
Sub-carrier Masking	4	0	22	5
RFI Notching Test	1	0	25	5
Throughput Test	8	2	42	1

These tests were initiated in January 2016 Plugfest "Report of January 25-29, 2016 G.fast Systems/Chipset Interoperability Plugfest", BBF2016.332.00