# Overview of Copper DSL and FTTN Solutions

**Ryan McCowan**
**Product Manager**
**November 16-17, 2010**

Let's talk about...
**BROADBAND** YOU CAN **Build On**

**Power & Tel**

**ADTRAN**

- Drivers for Access Architecture Decisions
- FTTx Overview and Enabling Technologies
- CO/RT
- FTTN
- Hybrid Architectures
- FTTC
- Ultra Broadband Ethernet – A New Architecture

# FTTx Access Architectures

- **What Drives Access Architecture Decisions?**
  - Bandwidth demands
  - Political/Regulatory requirements
  - Time to market constraints
  - Competitive threats
  - Capex Constraints

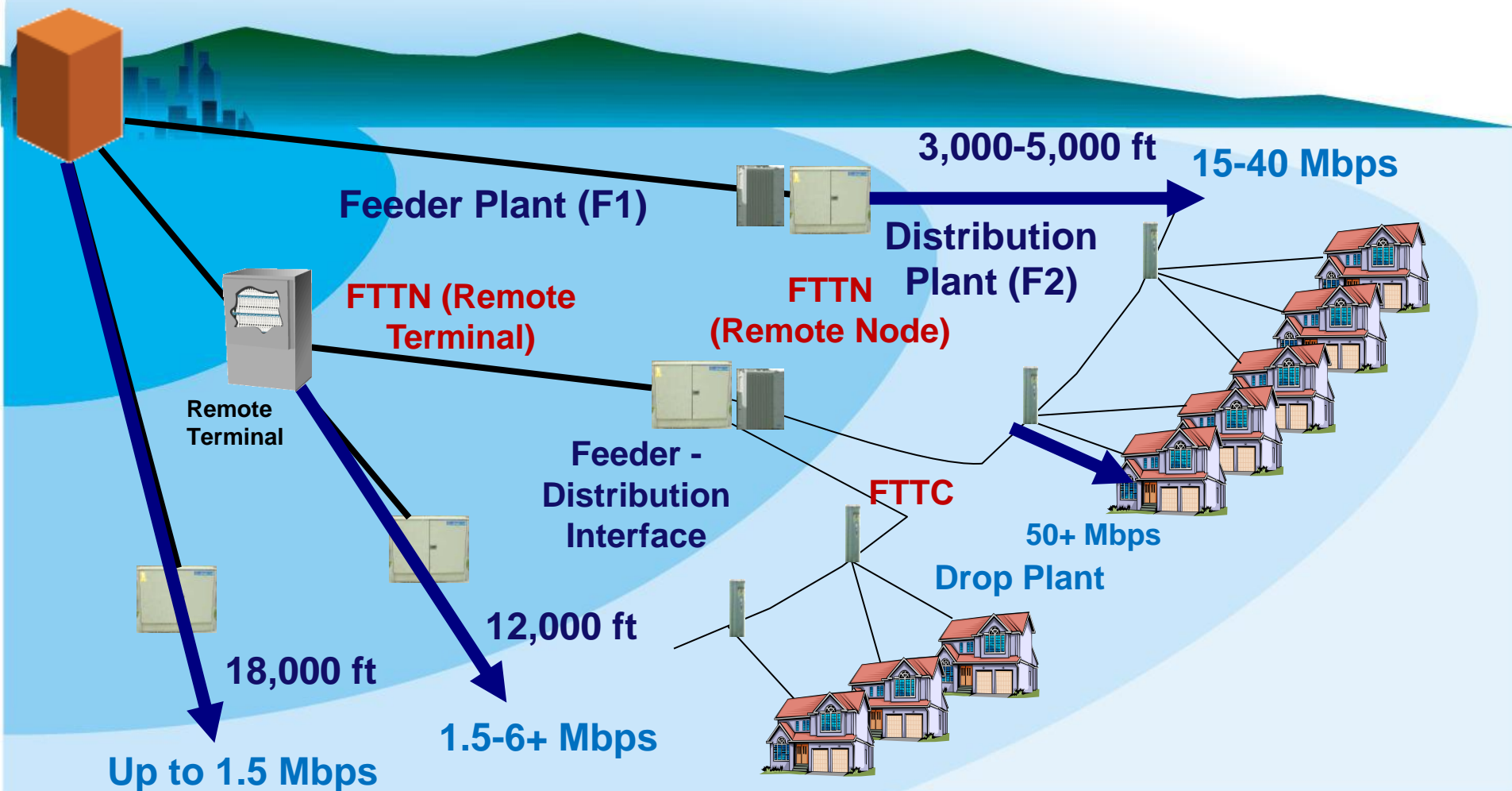- **Access Architecture Options**
  - CO/RT-based DSL
  - Fiber to the Node (FTTN)
    - ADSL2+
    - VDSL2
    - Bonded xDSL
  - Fiber to the Curb (FTTC)
  - Fiber to the Premise (FTTP)
    - GPON
    - Active Ethernet

- Goals
  - 2015
    - 50 Mbps down / 20 Mbps up actual data rates to 100 million homes
  - 2020
    - 100 Mbps down / 50 Mbps up actual data rates to 100 million homes
    - 4 Mbps down / 1 Mbps up actual data rates to all homes

- Components
  - Last mile Access
  - 2nd /Middle Mile Aggregation

- Properties
  - Peak Rates
  - Capacity to deliver "actual rates"
    - (95% percentile rate returned by speed test)

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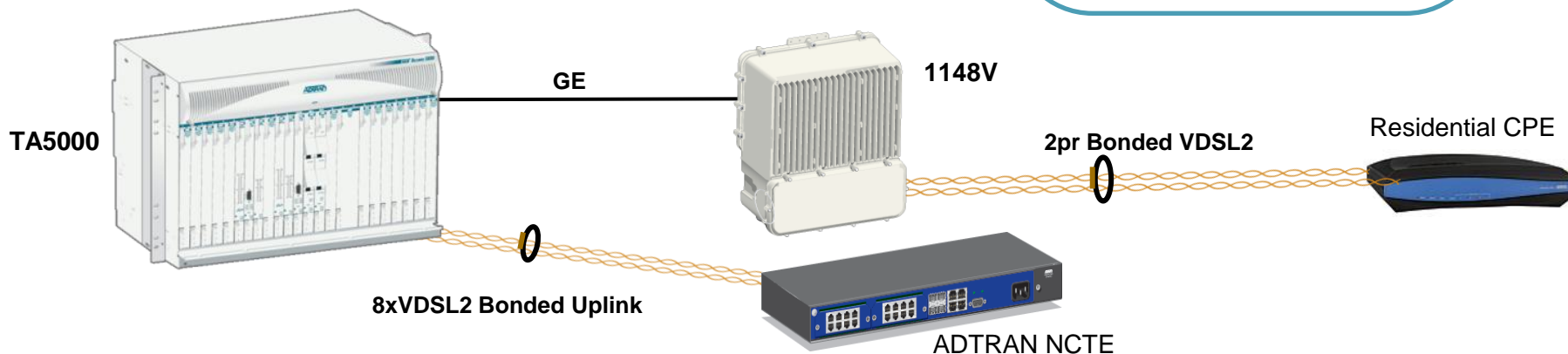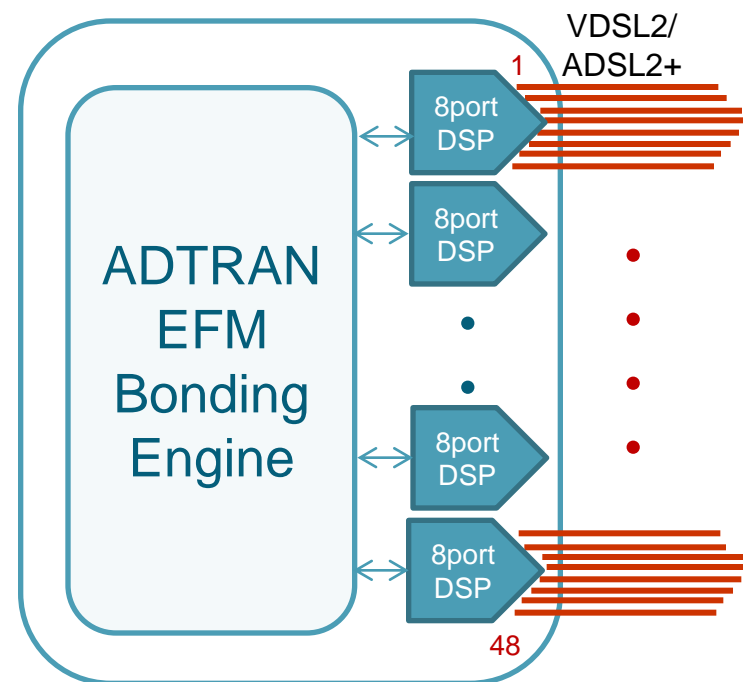- Ultra Broadband Ethernet – A New Architecture

# Access Network: Pushing Fiber Deeper

Central Office

Feeder Plant (F1)

3,000-5,000 ft  15-40 Mbps

FTTN (Remote Terminal)

Distribution Plant (F2)

FTTN (Remote Node)

Remote Terminal

Feeder - Distribution Interface

FTTC

50+ Mbps

Drop Plant

12,000 ft

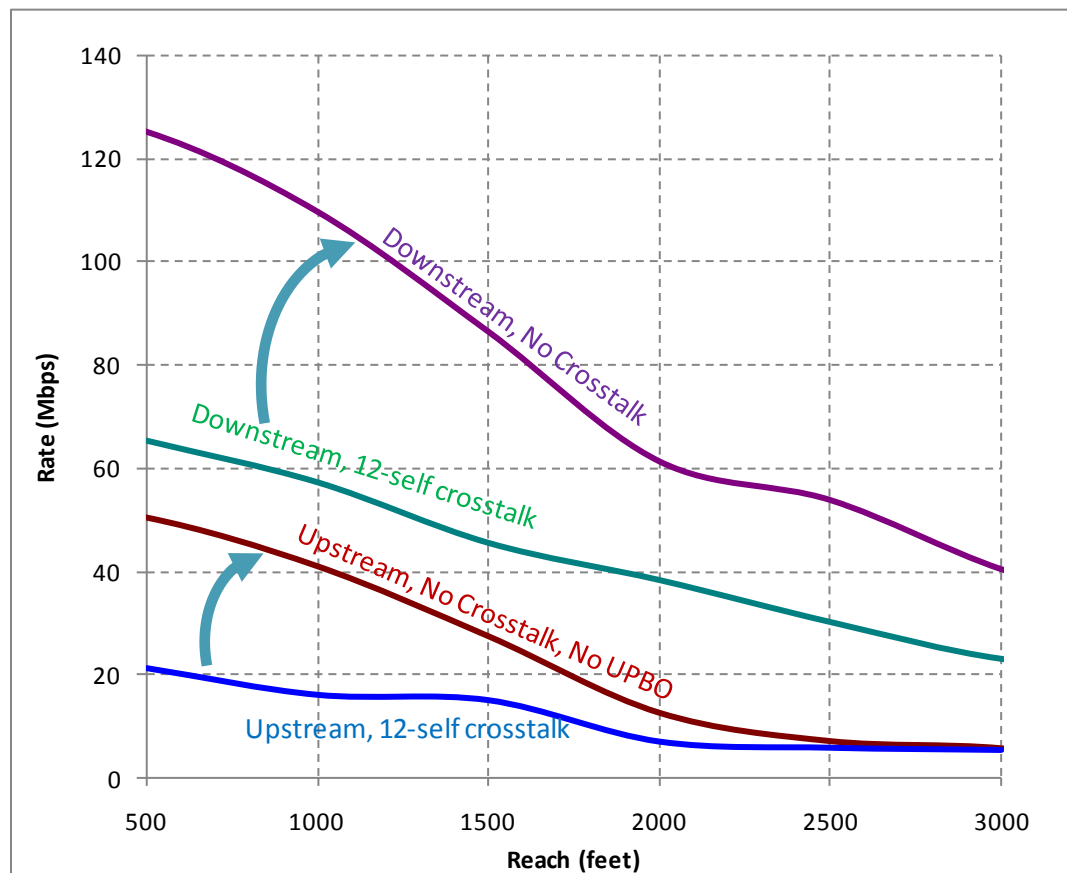18,000 ft

1.5-6+ Mbps

Up to 1.5 Mbps

## ADTRAN EFM Bonding Features

- VDSL2 DSLAMs leverage same EFM Bonding engine used in ADTRAN Carrier Ethernet solutions
- G.998.2-compliant
- Any-port bonding across the line card
- Up to 12 pairs per bonding group for business-class NCTE
- High-speed bonding engine allows for ultra high-speed service deployment (up to 200M over 2 pairs with Profile 17a)

## 48 Port VDSL2 Line Card

**ADTRAN**

- ## What Vectoring Provides
  - Eliminates self cross-talk on short copper loops
  - Significant gains on short loops (< 3 kft)

- ## Deployment Guidelines for Vectoring
  - Short loop nature of this technology leads to smaller node sizes
  - Need small-form-factor, remote DSLAMs to take advantage of cross-talk cancellation capabilities of vectoring



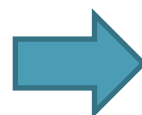*VDSL2 with vectoring is ideally suited for remote node deployments*

**ADTRAN®**

- Sealed DSLAM design eliminates the need for:
  - Expensive cabinet enclosures
  - Noisy, power hungry heat exchangers
  - Costly site construction

- 3$^{rd}$ generation sealed DSLAM design
  - 8+ years of engineering expertise in sealed DSLAM design
  - Over 50,000 units deployed in the field today

- Lower total landed cost for a sealed DSLAM changes the broadband business case



1$^{st}$ Gen 1124s          2$^{nd}$ Gen 1148s          3$^{rd}$ Gen Solutions
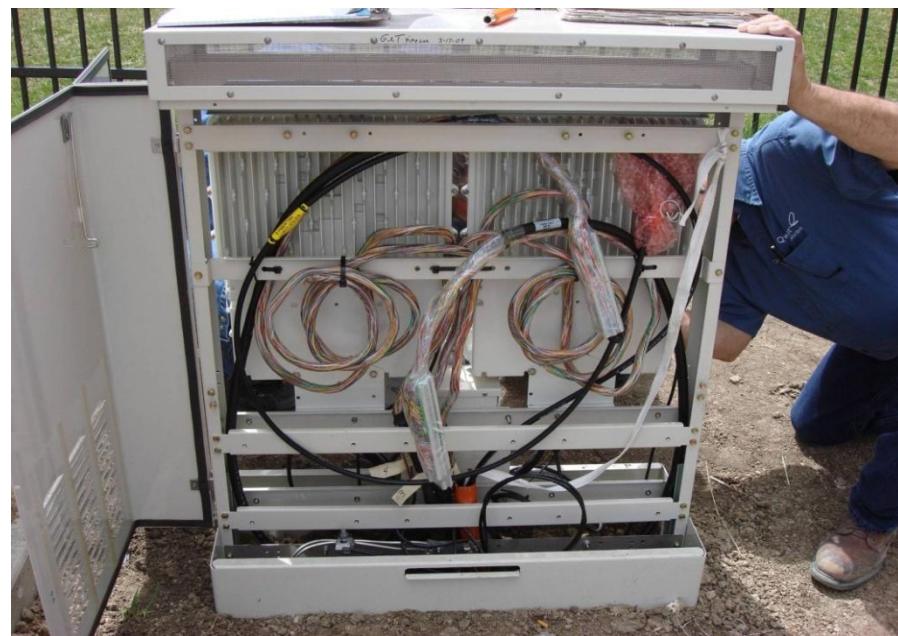
- **Deployment is greatly simplified using OSP DSLAMs**
  - No new right of way
  - No new pad work
  - Significantly lower shipping costs
  - Installation doesn't require a crane
  - Smaller crew onsite for installation
  - No expensive heat exchanger solutions
  - Lower power requirements

- **Electronics costs keep falling but total deployment costs aren't getting any cheaper**
  - Metal (i.e. cabinets) keeps climbing
  - Lower density areas can't prove in due to first cost turn-ups

## DEPLOYMENT COSTS OF CABINET vs. 1100 SERIES

| Item Description | Cabinet DSLAM | Total Access 1100 Series |
|---|---|---|
| Cost of Cabinet | $$$ | None |
| Cabinet Protection and Wiring | $$ | Integrated |
| Power System with Batteries | $$ | $ (span powering) |
| Power Pedestal | $ | None |
| Concrete Pad and Pad work | $$ | None |
| Labor Cost | $$ | $ |
| Cost of Crane | $ | None |
| Permits and Right of Way | $$ | None |
| Site Prep | $$ | None |
| Shipping | $$ | $ |
| Solutions Engineering | $$$ | $$ |
| Deployment Speed | Construction can take more than a month | 1 day |
| Revenue Losses Due to Installation Delays for Construction | Variable | None |
| Cost of Land Purchase or Lease | Variable | None |
| Total Deployment Cost | $25,000–$35,000 | $5,000–$7,000 |

*Deployment costs only. Cost of the electronics are not included.

ADTRAN

Sealed OSP DSLAMs in pedestals save thousands in site, prep, and placement costs when compared to traditional cabinets
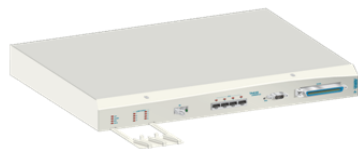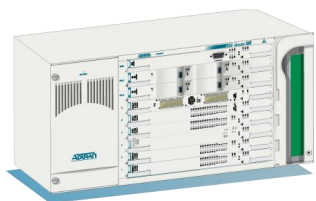


**Up to 192 Ports with Emerson CoolPed Pedestal**

- **Simplifies installation and reduces cost**
- No AC pedestal or meter required
- No local DC rectifier or battery backup required
- Cleaner, more compact remote footprint
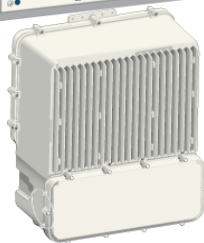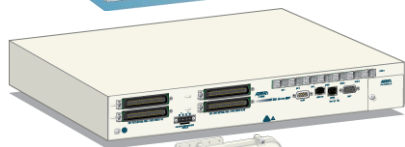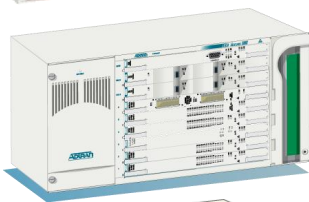- Centralizes DC power and battery backup plant

- Drivers for Access Architecture Decisions
- FTTx Overview and Enabling Technologies
- CO/RT
- FTTN
- Hybrid Architectures
- FTTC
- Ultra Broadband Ethernet – A New Architecture

**Broadband Product Suite for Copper and Fiber Delivery**

**Central Office**          **FTTN**          **FTTC**          **Customer Premises**

# Breadth of Services

**ADTRAN®**

## Broadband Access

## Services Migration

- VDSL2
- VDSL2 Combo
- DS1 MS
- ADSL2+
- ADSL2+ Combo
- Voice Gateway
- RPOTS
- DS1 PWE
- DS3 1 port
- CH DS3 MS
- DS3 4 port
- OC3 1 port
- GPON
- Active E
- Quad OLT
- OC3 4 port
- RPR
- GigE
- T-1
- HDSL
- ESHDSL
- DS1
- DS3
- CH DS3
- GigE 8 port

## Carrier Ethernet

# High Density Solution

- **Feature-rich Ethernet MSAP**
  - Standard GE network ports
    - 802.1Q, 802.1p
    - PPPoA to oE
    - DHCP Opt 82
    - IGMP aware
  - LAG / LACP for redundant uplink

- **IP DSLAM or BBDLC**
  - Feature-rich ADSL2+ or VDSL2
    - Bonding, oA to oE, backwards compatible
  - Long loop POTS – 1850 Ohm
    - VoIP transport
    - SIP, GR-303, TR008
  - Density
    - Up to 504 Combo/POTS ports per shelf
    - 2,016 Combo ports per rack
    - 1,280 ADSL2+/VDSL2 **with** splitters

- **Simple network scale**
  - No additional slots for scale (SM)
  - Utilize copper or fiber GE SFPs
  - 1, 2.5, and 10Gb options

**Redundant GigE Or 10 GigE**

**ADTRAN**

- ADSL2+ 32-Port with Splitter Access Module
  - Full compliance with all standard ADSL modes
  - Auto-negotiation to CPE
  - "Make before break" POTS connectivity
  - 10 year warranty splitter
  - Bond any 2 ports
  - Annex M for symmetric service offering

- Combo 24-Port Access Module
  - POTS, ADSL2+ and splitters
  - High density solution
  - 504 ports per TA5000
    - 2,016 per rack

- Copper will continue to be leveraged
  - Easy migration to fiber when ready
  - Swap a module…

- VDSL2 32-Port with Splitter Access Module
  - Support for multiple profiles
  - Fallback to ADSL modes
  - Completely G.993.2 compliant
  - Support for "5 Band" VDSL2: Profiles 8a, 8b, 8c, 8d, 12a, 12b, 17a
  - EFM bonding

- VDSL2 Combo 24-Port Access Module
  - POTS, VDLS2 and splitters
  - Early market entry
  - 504 ports per TA5000
    - 2,016 per rack

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# Access Network: Pushing Fiber Deeper

**Central Office**

**Feeder Plant (F1)**

**3,000-5,000 ft**

**15-40 Mbps**

**Distribution Plant (F2)**

**FTTN (Remote Terminal)**

**FTTN (Remote Node)**

**Remote Terminal**

**Feeder - Distribution Interface**

**FTTC**

**100+ Mbps**

**Drop Plant**

**12,000 ft**

**18,000 ft**

**1.5-6+ Mbps**

**Up to 1.5 Mbps**

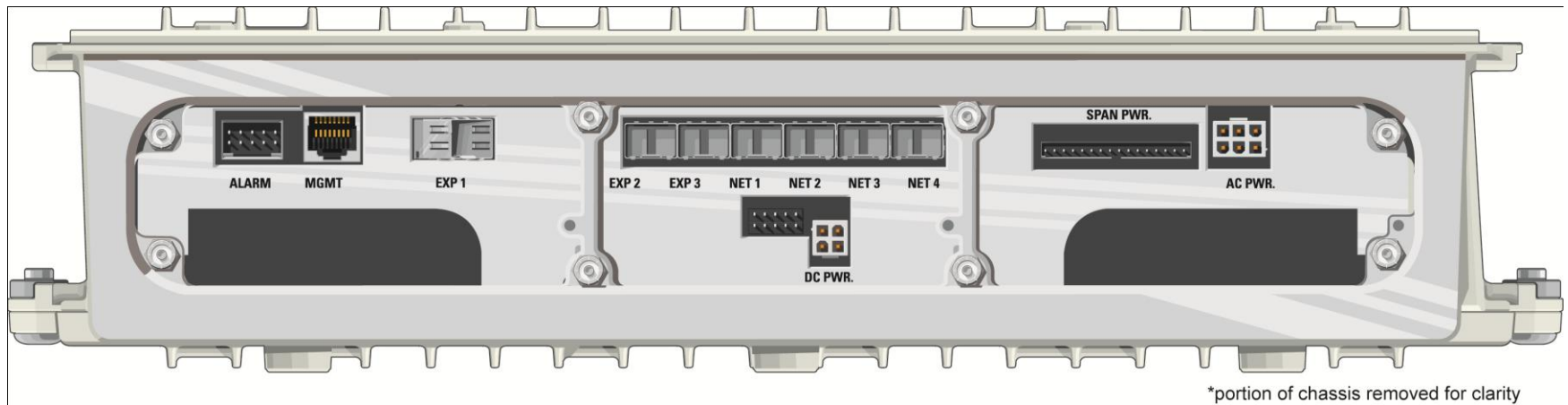- ## Standard Gigabit Ethernet uplinks

- ## 48 ADSL2+ ports per unit
  - Support for G.998.1 Bonded ADSL2+ (ATM Bonding)
  - Support for PTM mode of operation to remove ATM overhead (future)

- ## GR-487 compliant (sealed and weatherproof)

- ## -40 to +70 C (-40 to +158 F) operating temperature range

- ## Universal Power Supply (AC, DC, Span with a single power supply)

Total Access 1148A

21.8"

16.7"

- **Standard Gigabit Ethernet uplinks**

- **48 ports of G.993.2-compliant VDSL2 in a single compact OSP DSLAM**
  - Support for "5 Band" VDSL2: Profiles 8a, 8b, 8c, 8d, 12a, 12b, 17a
  - Backwards compatible with ADSLx Modems

- **GR-487 compliant (sealed and weatherproof)**

- **-40 to +70 C (-40 to +158 F) operating temperature range**
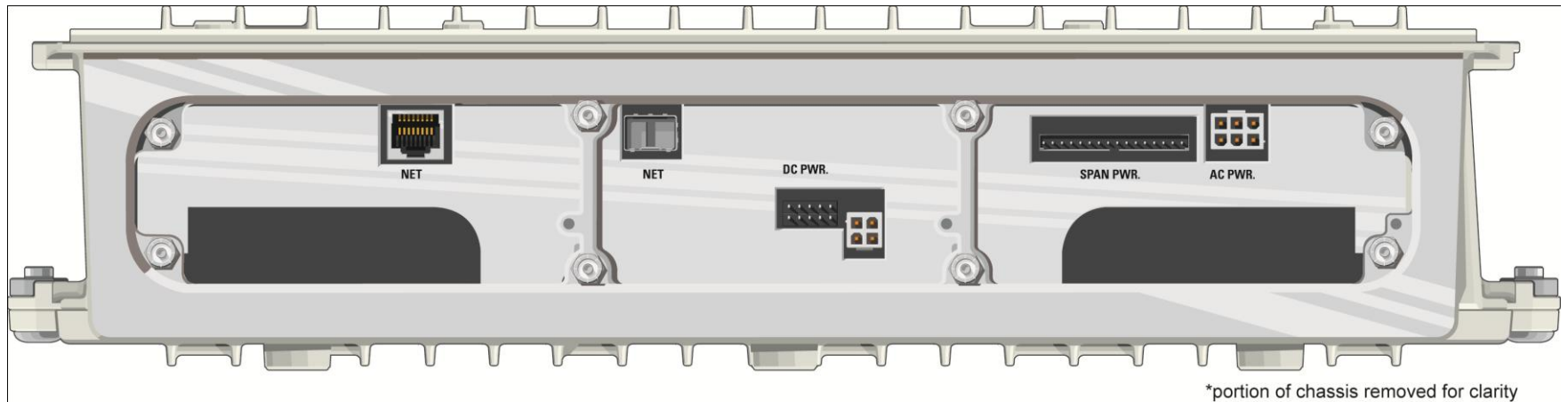
- **Universal power supply (AC, DC, and span powering in a single part number)**

Total Access 1148V

21.8"

16.7"

**Total Access 1148V Host  (Integrated SM)**



ALARM  MGMT  EXP 1  EXP 2  EXP 3  NET 1  NET 2  NET 3  NET 4  SPAN PWR.  AC PWR.  DC PWR.

*portion of chassis removed for clarity

**Total Access 1148V Client (Single GE Uplink to Host )**



NET  NET  DC PWR.  SPAN PWR.  AC PWR.

*portion of chassis removed for clarity

Standard 25-pair amp champ connectors and integrated SFP cages allow for flexible cabling options and field replacement without the need for re-splicing

**Ethernet Switch**

NxGE

NxGE

**Total Access 1148A/V Host**

Ethernet

VDSL2

VDSL2

VDSL2

VDSL2

Local GE Subtending
(up to 192 ports per node)

**Total Access 1148A/V Clients**

# Scalable from 48 to 192 ports per node

- 1248A Host: 2 x GE uplink, 3 x GE ports for subtending

- 1248A Client: Single GE uplink (RJ45 or SFP)

- 48 ADSL2+ ports with integrated splitters

- Single IP address management of 192 ports



1248A  Host

1 RU

1248A  Client

# Total Access 1248V

- 1248V Host: 4 x GE uplink, 3 x 1/2.5GE ports for subtending

- 1248V Client: Single 1/2.5 GE uplink (RJ45 or SFP)

- 48 VDSL2 ports with integrated splitters

- Single IP address management for 192 ports

1248V Host



1.5 RU

1248V Client

**Ethernet Switch**

Data/
Video

NxGE

NxGE

VDSL2

VDSL2

# Scalable solutions from 48 to 192 ports per node

- 24 ADSL2+ plus POTS ports

- GigE or 8xHDSL4 EFM network connection

- 8xHDSL4 EFM host version has integrated GigE for future migration to fiber

- Capable of subtending additional 1124Ps (2nd-gen HW early 2011)

- VoIP to Total Access 5000 VG which converts to GR-303 (software upgradeable to SIP)

- Supports both span and DC power

- GR-487 compliant (environmentally sealed and weatherproof)

**Total Access 5000 COT**

**Legacy RT or ORB**

**Total Access 1124P**

**TDM Network**

HDSL4

GR-303, TR-08

PSTN

**Total Access 1U LPU Shelf**

8 Line Power Loops

ADSL2+ w/ POTS

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## Best-in-Class Carrier Ethernet Products

## Market-leading Sealed FTTN DSLAMs



## Industry's First Sealed DSLAM with > 100 Mbps Bonded Copper Backhaul

*GE*

**CO or RT**

**EFM Aggregator**

**>75 Mbps @ 10,000 ft.**

**>100 Mbps @ 8,000 ft.**

*Integrated Fiber Uplinks*

**Remote Node**

**1148A-DMT**

*Cross-connect*

**10+ Mbps ADSL2+**

**10+ Mbps ADSL2+**

*Line Powering over the Data Pairs Reduces Pair Constraints and Lowers Deployment Costs*

- Bonded DSL copper transport to sealed Total Access 1148A-DMT DSLAMs located closer to the subscriber to drive higher bandwidth services

- Integrated bonded DSL copper transport on existing pairs eliminates multiple components and reduces pair requirements, delaying the expense of fiber deployment

# Total Access 1148A-DMT

- 8xADSL2+ Bonded EFM or 2xGE Uplink Options

- 48 ADSL2+ subscriber interfaces

- Integrated GE switch for expansion

- Universal Power Supply (AC, DC, Span with a single power supply

Total Access 1148A-DMT

22"

17"

|  | Bonded Copper Backhaul Pair Requirements | Backhaul Bandwidth Capabilities | Copper Bonding Method | Fiber Upgrade |
|---|---|---|---|---|
| Legacy Bonded T1 IMA 1148s | 16 pairs for local power, 24 pairs for line powering | 12 Mbps symmetric | IMA Bonding (ATM Based) | Need to deploy external 1100F |
| Total Access 1148A-DMT | 8 pairs (includes line powering pairs) | 100+ Mbps down, 10-20 Mbps up | EFM Bonding (Ethernet Based) | Integrated GE uplinks (just add SFPs) |

**Fiber-fed DSLAM w/ Multi-pair DSL Bonding**

**Copper-fed DSLAM w/ Multi-pair DSL Bonding**

**Copper-fed DSLAM w/ Multi-pair DSL Bonding**

NxGE

**75 Mbps @ 10 kft (8 Pairs)**

**75 Mbps @ 10 kft (8 Pairs)**

Local xDSL Subscribers

Local xDSL Subscribers

Local ADSL2+ Subscribers

Distribution Area 1

Distribution Area 2

Distribution Area 3

Extended High Speed Service Range Over Copper

Fiber-fed DSLAM w/ Multi-pair DSL Bonding

Copper-fed DSLAM w/ Multi-pair DSL Bonding

NxGE

320-480 Mbps shared transport

Local VDSL2 Subscribers 40-60 Mbps

Local VDSL2 Subscribers 40-60 Mbps

2000 ft

2000 ft

4000 ft @ 15-20 Mbps

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Drop Plant

12,000 ft

18,000 ft

1.5-6+ Mbps

Up to 1.5 Mbps

**TA5000 COT**

**TA5000/5006 RT**

**TA1108VP Series**
8 PortsVDSL2
& POTS

GE

(Chaining Option)

NxGE

GE

**TA1108VP**

**LPU**

8 Ports VDSL2 &
POTS

**Remote Power
Node**

Line Power
Loops

GR-303,
GR-08

Class 5 Switch
or
Softswitch

**Line Powering
Upgrade Option**

- Small form factor: (16" H x 10" W x 4" D)
- Designed for above or below ground deployment
- 12-pair copper cable (8 POTS+VDSL2 plus 4 powering pairs)
- IP68-compliant RJ45 Ethernet interface for management
- Fixed optical interface (two single-fiber connections – 1310nm Tx/1490nm Rx on fiber 1, 1490nm Tx/1310nm Rx on fiber 2) with quick disconnect fiber connector

**1108VP**

**1108VP**

VDSL2 and POTS

**GE Exp.**

**GE Uplink**

- **Network and Subscriber Interfaces**
  - 2 single fiber GE ports (uplink & expansion)
  - 8 POTS plus VDSL2 interfaces

- **VDSL2 Capabilities**
  - G.993.2-compliant VDSL2 support
  - Profile 17a provides 75+ Mbps down, 45+ Mbps up @ 500 ft
  - VDSL2 bonding support in future software release

- **POTS Capabilities**
  - GR-08, GR-303, and SIP (future) capabilities
  - TA5000 VG utilized for TR-08 and GR-303 functionality

*Utilizes functionality of TA5k VDSL2 Combo Card*

**CAD12 Pedestal**

**Indoor**



*The Total Access 1108VP is a single box solution for all FITL ONU deployment scenarios*

*(ADTRAN has developed mounting kits for each deployment option)*

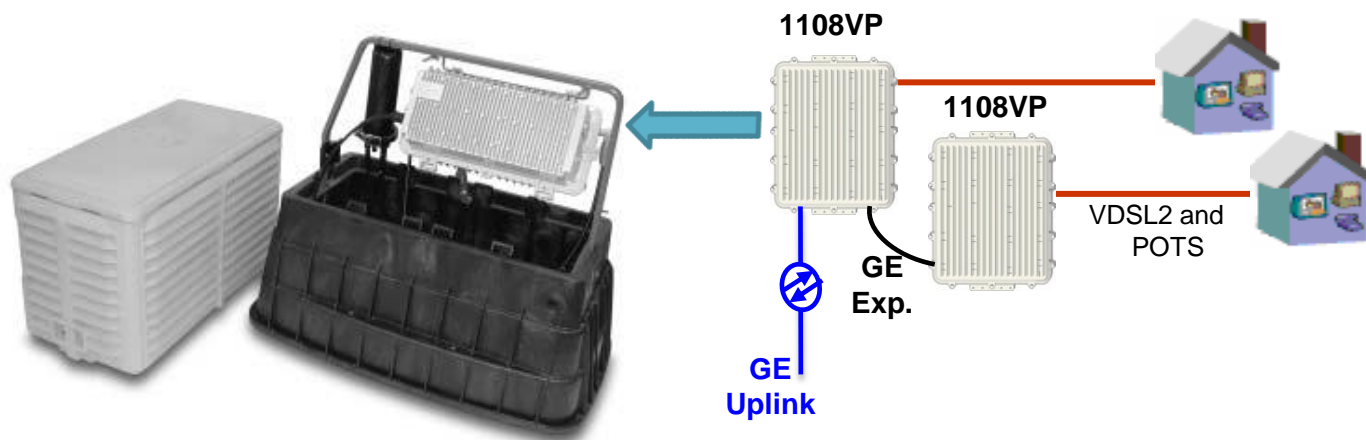**Below Ground Vault**

**Doghouse Pedestal**

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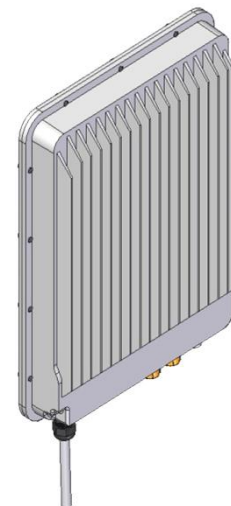- Ultra Broadband Ethernet – A New Architecture

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Feeder - Distribution Interface

FTTC

100+ Mbps

Drop Plant

12,000 ft

18,000 ft

1.5-6+ Mbps

Up to 1.5 Mbps

fiber Here

Want to deliver super fast internet here

Note the road and sidewalk

## FTTH Cost prohibitive in such a scenario

**Trench fiber in sidewalk to home ($$$)**

**Add New Optical Access Point ($)**

Sidewalk/Road

**Install ONTs (one per home) ($$)**

**Install Ethernet from ONT into home ($$)**

Opt. Spli...

ONT
ONT
ONT
ONT
ONT
ONT
ONT
ONT

STOP

**Problem Area $$$**

**Distribution Point (DP)**
[Subscriber Drop Pedestal]
- 8-16 homes per DP
- Drop length < 200ft
- Pole mount or below ground mount in hand hole

**This Type of FTTH Deployment often cost prohibitive**

Sidewalk/Road

ONT

ONT

**Ultra Broadband Ethernet ONT ($)**

ONT

ONT

**Easy Install ($)**

UBE ONT

ONT

**Ethernet over Existing Subscriber Drops**

ONT

ONT

ONT

**Delivers 100Mbps or more at a fraction of the cost and time of FTTH**

STOP

GO!

up to 100 meters (300ft)

Point-point Ethernet
or PON

UBE ONT

**Existing subscriber drop**

Existing Copper

power

**Min 100Mbps x 100Mbps Ethernet**

Adapter   100BaseT

← Low voltage backpower

**Ultra Broadband Ethernet ONT**
- **Sealed and submersible**
  - install anywhere, zero maintenance
- **Very low power**
  - less than 10W for 8 ports
- **Extremely small**
  - 4" x 14"

ADTRAN is Green

- **Easy Install**

- **Converts external signal to 100BaseT (GbE in future)**

- **Provides back power to UBE ONT**

Minimum 100Mbps in both directions, very fast to deploy, very low CAPEX & OPEX

- ✓ **Fast Downstream:** Minimum 100Mbps

- ✓ **Fast Upstream:** Minimum 100Mbps

- ✓ **Low CAPEX & OPEX**:
  - leverages existing subscriber drop & **easy install**
  - No maintenance ONT – install it and forget about it
  - Low cost CPE option – simple media adapter

- ✓ **Accelerate Revenue: hours not months**
  - No fiber trenching and network power delays
  - Easy install

- ✓ **Flexible**
  - Very small, sealed and submersible – install anywhere
  - Can leverage GbE, GPON and Active Ethernet on uplink
  - Small port granularity (8 port)

- ✓ **Ultra Green**: ~1 Watt per subscriber

**ADTRAN®**

| FTTH in Challenging Environment (road/sidewalk) | UBE in Any Environment |
|---|---|
| Costly & disruptive fiber trenching in road/sidewalk | **Use existing subscriber drop (up to 200m)** |
| Truck Roll to install outdoor ONT for every subscriber | **No outdoor ONT required** |
| Truck Roll to run Ethernet from ONT into home | **Easy Install in home** – no need to run cables from ONT |
| Takes months and sometimes years to roll-out | Complete install and turn up in days |

## Ultra Broadband Ethernet enables Network Wide Deployment
### *Superior Performance at a fraction of the Cost*

- Ultra Broadband Ethernet solves some real problems for carriers and consumers

- It provides a great alternative solution to FTTH in many scenarios

- Trials underway with Tier 1 Operators in Europe, North America and the Middle East

- Commercial Availability first half 2011

- ADSL2+: basic internet access & SD video – up to 25Mbps

- FTTN/Cabinet w VDSL2:
  - Up to 100Mbps DS, 50Mbps US (1,400 ft to 2,700ft depending on vectoring and bonding)
  - Appropriate for cross connects with short loops

- FTTC [Fiber To The Curb]:
  - Appropriate for Greenfield in certain cases

- FTTP: Greenfield and select brownfield
  - Can easily do 100Mbps and beyond
  - Only cost effective in greenfield or certain brownfield scenarios
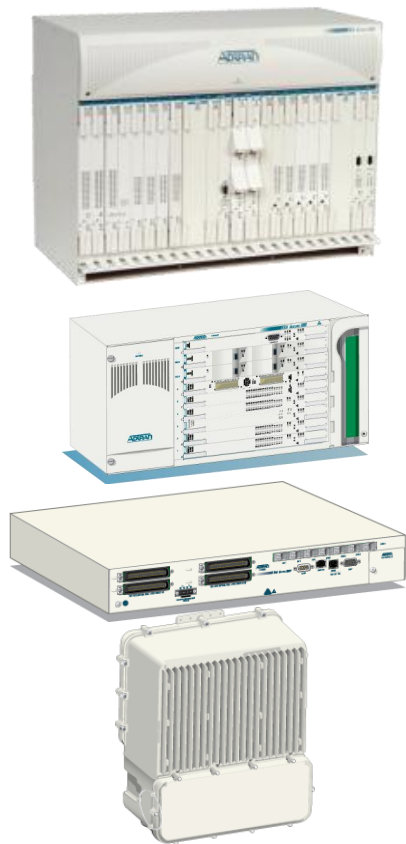
- Ultra Broadband Ethernet (cont'd)

- **Ultra Broadband Ethernet**
  - Brownfield region where fiber installation is difficult
    - Super fast internet is desired but FTTP doesn't prove in due to high cost of fiber installation
  - Highly competitive region where time to market is critical
    - Regaining a lost customer is very expensive. Ultra Broadband Ethernet can be deployed quickly and tactically as defense against cable providers
  - Where likely take rate is uncertain
    - Can deploy an 8 port Ultra Broadband Ethernet solution for same price as one FTTH customer!
  - Multi-dwelling units: leverage existing wiring and capitalize on easy install advantage
  - Others?

**Broadband Product Suite for Copper and Fiber Delivery**



**Central Office**     **FTTN**     **FTTC**     **Customer Premises**

# BACKUP

**VDSL2 Downstream and Upstream (Profile 17a - 24 Self, 24 AWG)**



30M to 35M 24AWG;
25M to 30M 26AWG

Downstream

Upstream

Rate (Mbps)

Loop Length (kft)

xDSL Comparison – 12 Self Disturbers

**VDSL2 Superior for:**
**- Very High Rates**
**- Very Short Loops**

Legend:
- Bonded 8a VDSL2+
- 8a VDSL2
- Bonded ADSL2+
- ADSL2+

**Bonded ADSL2 and Bonded VDSL2 8a**
**Provide Similar Reach at ~30 Mbps**

**Target Range for Enhanced**
**Broadband Services**

**Lower Cost/Port ADSL2+**
**Provides Better 10 Mbps Reach Compared to VDSL2**

VDSL2 Profile 17

VDSL2 Profile 12

VDSL2   Profile 8

ADSL2+

HAM

Plan 998

U0   D1   U1   D2   U2   D3

0.138   3.75   5.2   8.5   12   17 MHz

- D3 usable out to 610 m (1968 ft)
- U2 usable out to 900 m (2953 ft)
- D2 usable out to 1200 m (3937 ft)
- U1 usable out to 1300 m (4265 ft)
- HAM Bands:  1.81-2 Mhz, 3.5-4 MHz, 7-7.3 MHz
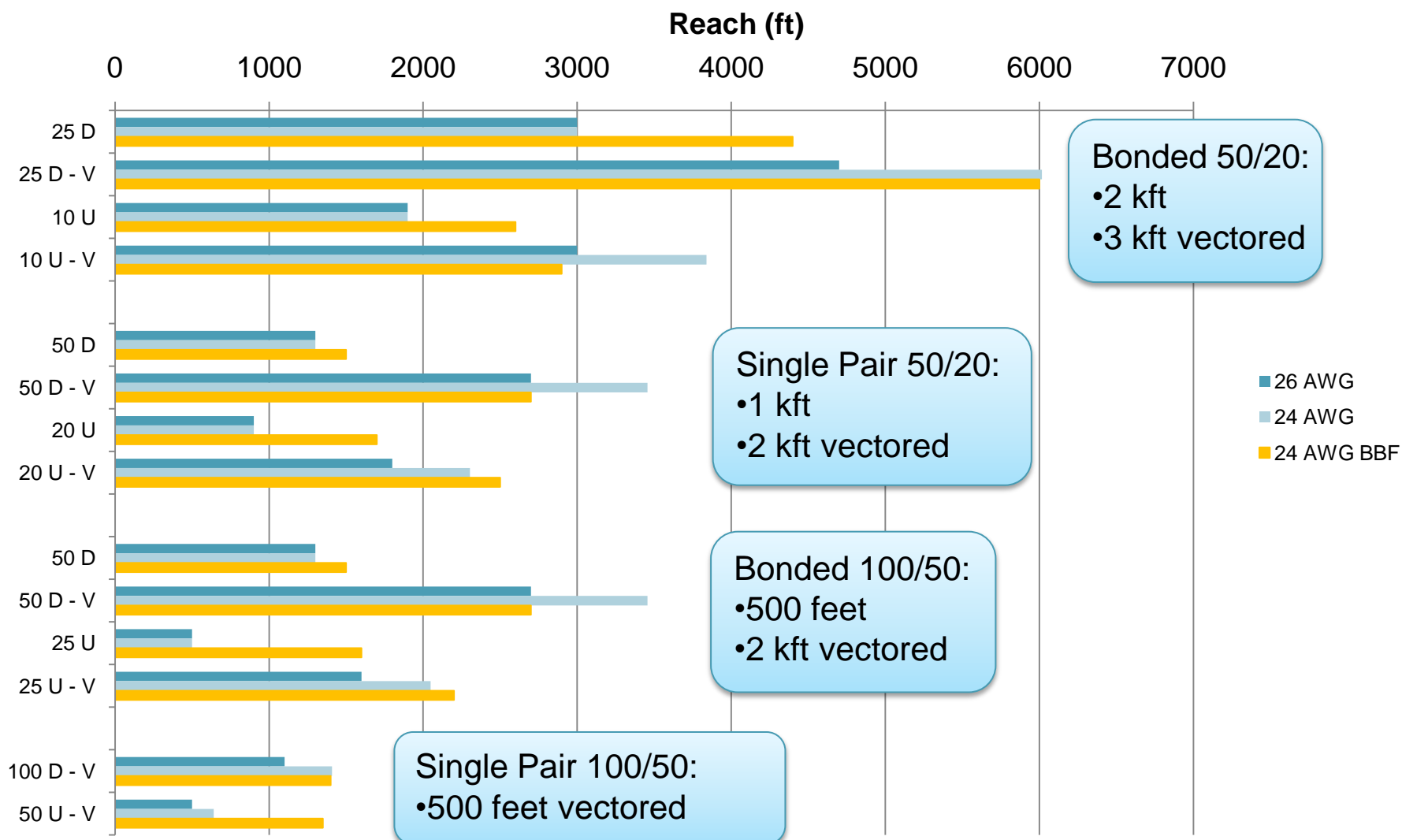
*Loop lengths must be reduced in order to take advantage of high frequency VDSL2 bands*
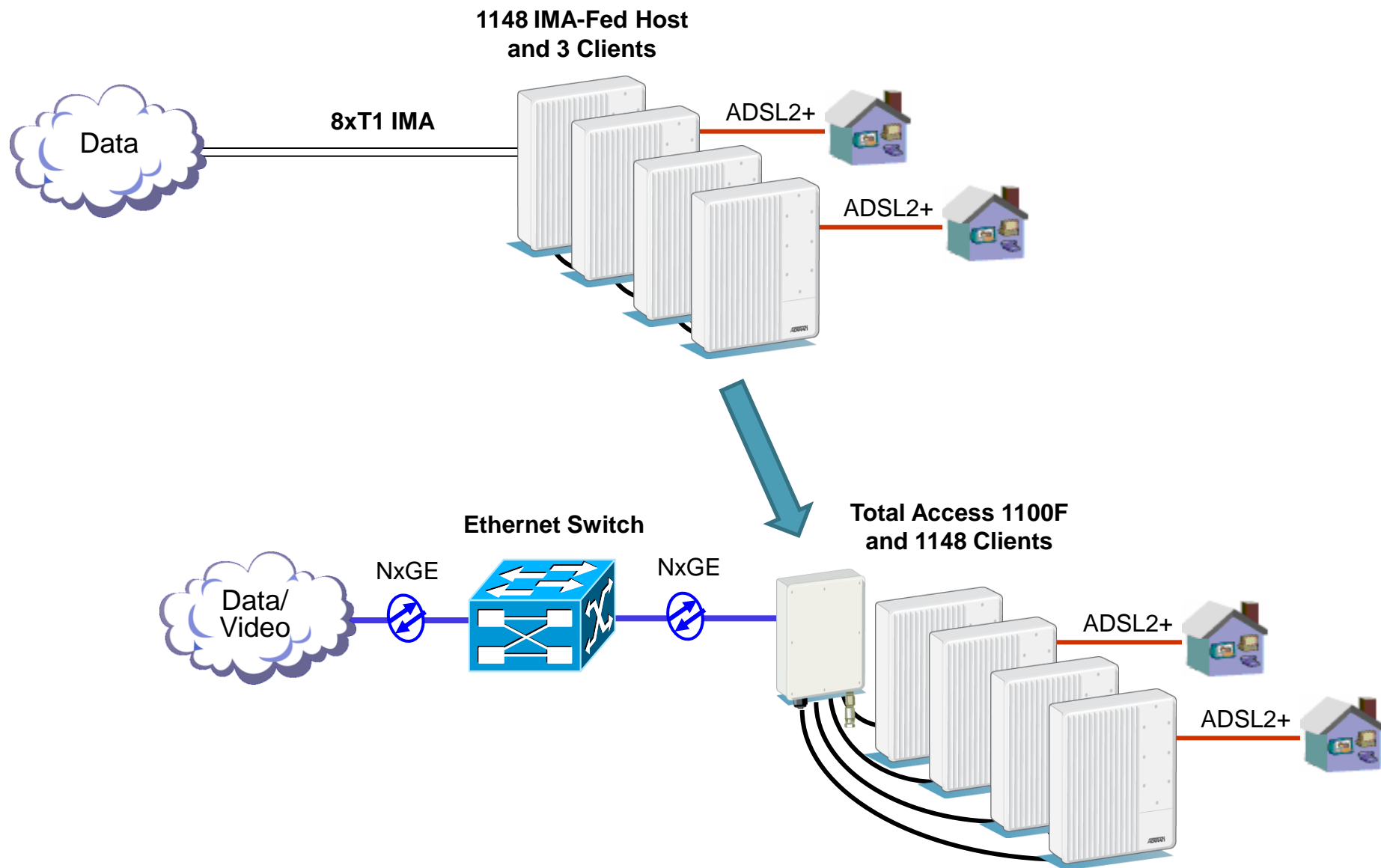
**Reach (ft)**

Chart categories (top to bottom): 25 D, 25 D - V, 10 U, 10 U - V, 50 D, 50 D - V, 20 U, 20 U - V, 50 D, 50 D - V, 25 U, 25 U - V, 100 D - V, 50 U - V

X-axis: 0, 1000, 2000, 3000, 4000, 5000, 6000, 7000

Legend:
- 26 AWG
- 24 AWG
- 24 AWG BBF

Callout boxes:
- Bonded 50/20:
  - •2 kft
  - •3 kft vectored
- Single Pair 50/20:
  - •1 kft
  - •2 kft vectored
- Bonded 100/50:
  - •500 feet
  - •2 kft vectored
- Single Pair 100/50:
  - •500 feet vectored

*Nominal Rates based on measured Profile 17a performance with 12 disturber w.c. self crosstalk, V-denotes measured performance in -140 dBm/Hz white noise, approximately the limit that can be achieved with vectoring.  Profile 30a may boost upstream reach at high rates*

**1148 IMA-Fed Host and 3 Clients**

Data

**8xT1 IMA**

ADSL2+

ADSL2+

**Ethernet Switch**

Data/ Video

NxGE

NxGE

**Total Access 1100F and 1148 Clients**

ADSL2+

ADSL2+

**1248 IMA-Fed Host and 3 Clients**

**8xT1 IMA**

Data

ADSL2+

ADSL2+

**Ethernet Switch**

**Total Access 1200F and 1248 Clients**

NxGE

NxGE

Data/Video

ADSL2+

ADSL2+