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Comparing the DOCSIS® 3.1 and HFC Evolution to the FTTH Revolution

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Technical Acknowledgements:

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Disclaimer

All economic estimates may not represent actual build and equipment costs. The cost estimates for Verizon were based on a 2010 Associated Press article and AT&T published material. The Cable HFC and FTTH economic estimates contain inputs from 3rd party and ARRIS for construction, installation, labor, materials, current and future equipment estimates as well as our assumptions of network architecture and topology. These use cases were compiled independent from the cable operators. The use cases are based on an extremely small sample size and actual build costs may vary widely market by market. This material is for information and illustrative purposes only and should not be considered or derived as actual results. It is not, and should not be regarded as actual cost estimates. Comparisons between Verizon, AT&T, and these use cases should not be considered as a direct comparison because the assumption are not known and certainly not aligned. In addition all of these estimates assume to varying degree different starting points or rather previous investments, which may not be represented in these costs as these are sunk costs. The core purpose of this data is to show relative difference for a particular set of use case migration options and should be used for discussion purposes only. The estimates expressed in this material are subject to change without notice. Reasonable people may disagree about the opinions expressed in our analysis and results. There are many other factors that were not considered that may impact the estimates and illustrate a significantly different result. It is strongly recommended that individuals and companies perform their own analysis based on their environment and costs.

Areas of Analysis

- Wireline Network Overview and Evolution
- Telco Network Migration Assessment
- Cable Operator Network Migration Assessment
- Data Capacity Comparisons
- Conclusions and Recommendations

Key Questions

Some MSOs are wondering if:

1. **An evolutionary approach** is best, which may include deploying fiber deeper with HFC and smaller nodes leveraging the coax to the home and then migrating to FTTH on an as needed basis, or if

2. **A revolutionary approach** is best, which may include stopping the investment in HFC and DOCSIS® 3.1 and just moving to fiber to the home and PON.

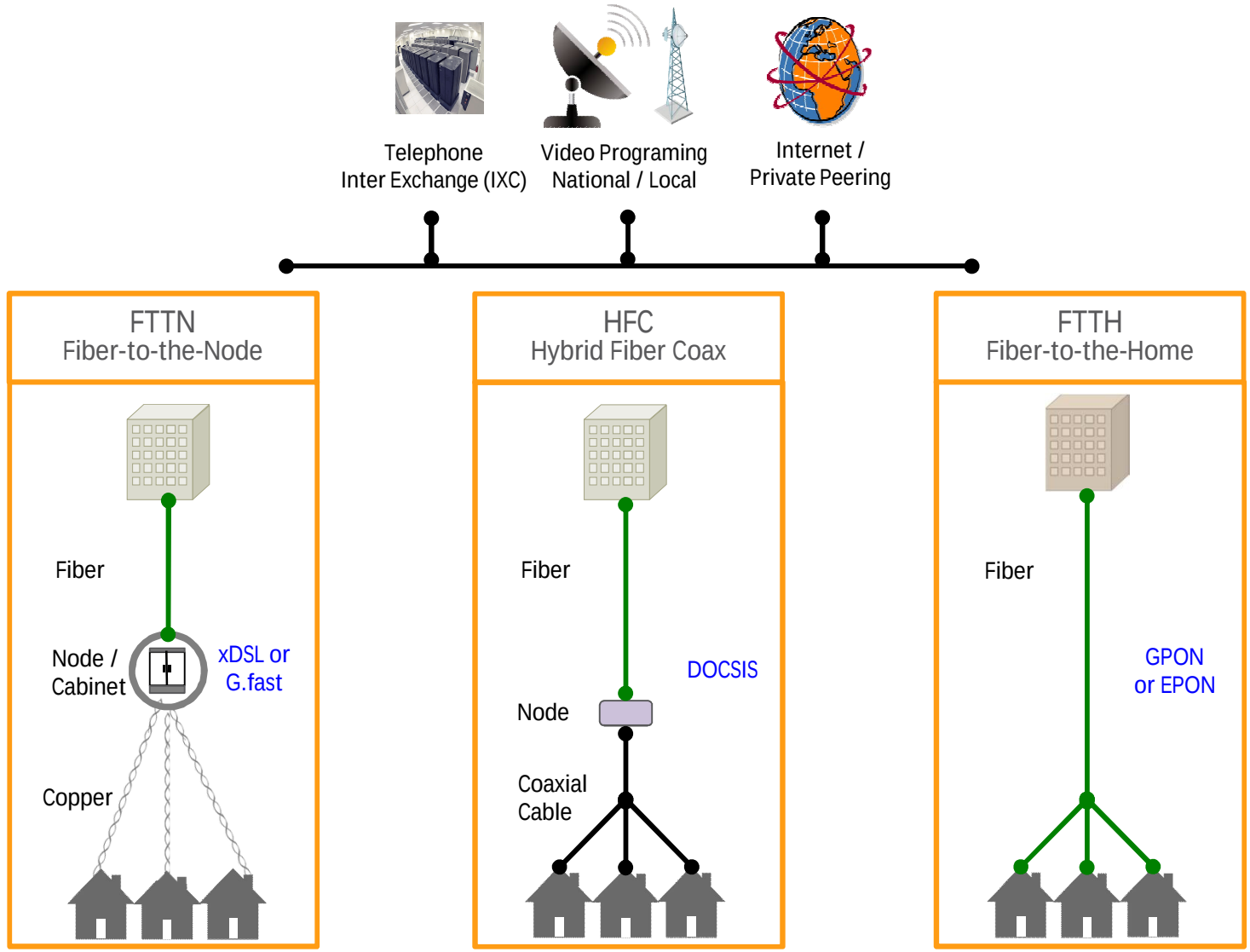
Purpose of the Paper

1. **Focuses completely on the existing network migration options and not new build or the MDU market segments**

2. **Describes migration options using CTTH & FTTH**

3. **Economics of CTTH & FTTH migration options**

Next Generation Wireline Broadband Networks



Network Technology Overview

FTTN (Fiber to the Node/Neighborhood)

- Fiber is deployed to the neighborhood outdoor Telco cabinets housing VDSL2 terminals
- Leverages copper telephone twisted pair lines using VDSL2 and in the future G.fast
- Capacity / speed of VDSL2 varies on distance from the node/cabinet and home
- FTTN + VDSL2 is a point-to-point (P2P) technology to VDSL2 terminal and then shared traffic
- VDSL2 and G.fast should have backward compatibility

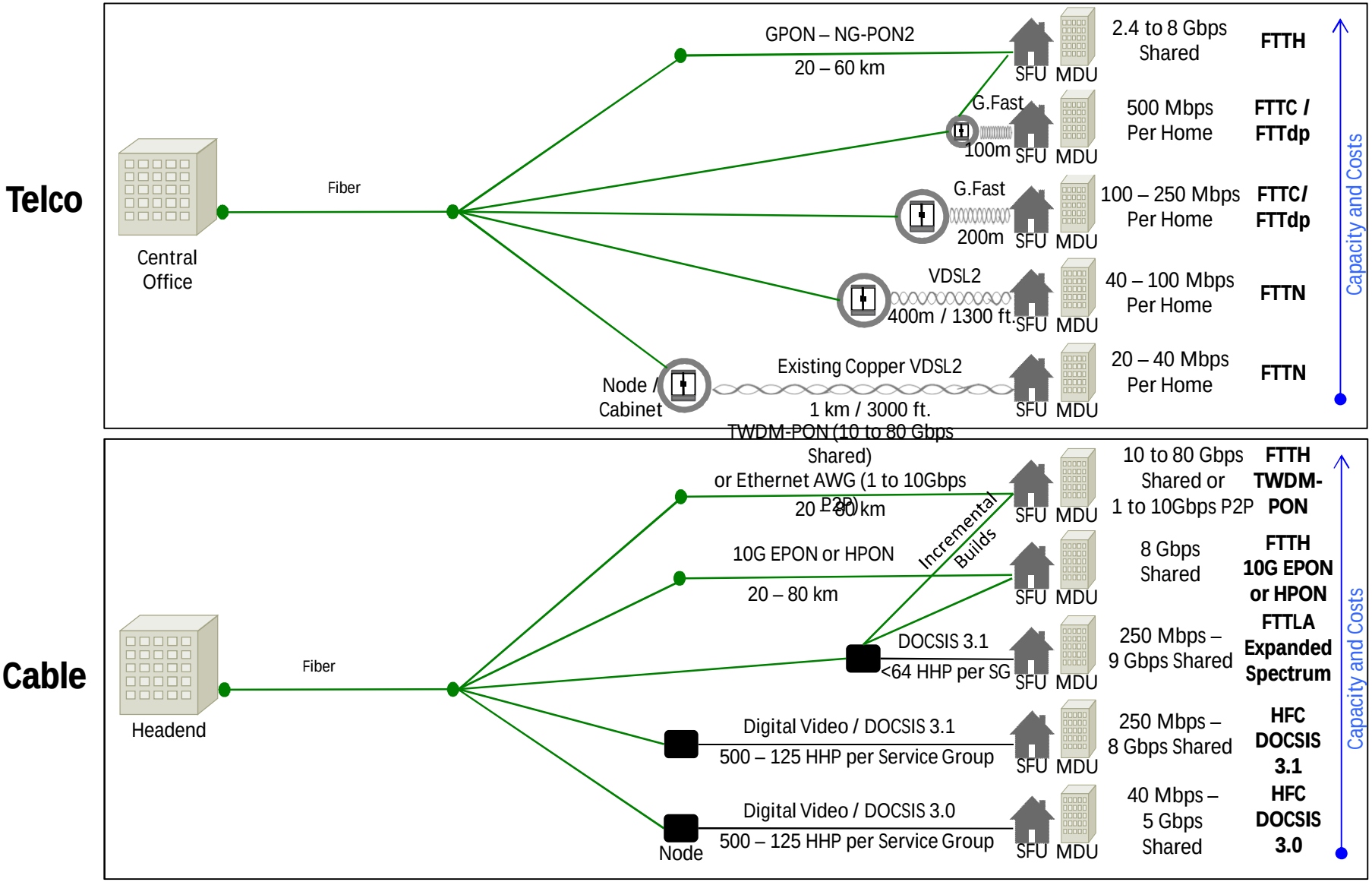
HFC (Hybrid Fiber Coax)

- Data services uses technologies defined by CableLabs
- DOCSIS 1.0 (Data Over Cable System Interface Specification) was released in 1997
- DOCSIS has release five (5) specification enhancements all with backward compatibility
- DOCSIS 3.1 offers multiple Gbps data rates capacity / speed varies based on spectrum allocation

FTTH (Fiber to the Home)

- Capacity / speed varies on technology selected
- FTTH use many different technologies (IEEE EPON, ITU-T GPON, IEEE Ethernet, RFoG, HPON)
- Significant upfront capital remains a challenge
- Highest cost metrics: cost per HHP, cost to connect homes, and cost per subscriber served
- Lowest Operational costs due to all passive network and lowest cost per bit remain compelling

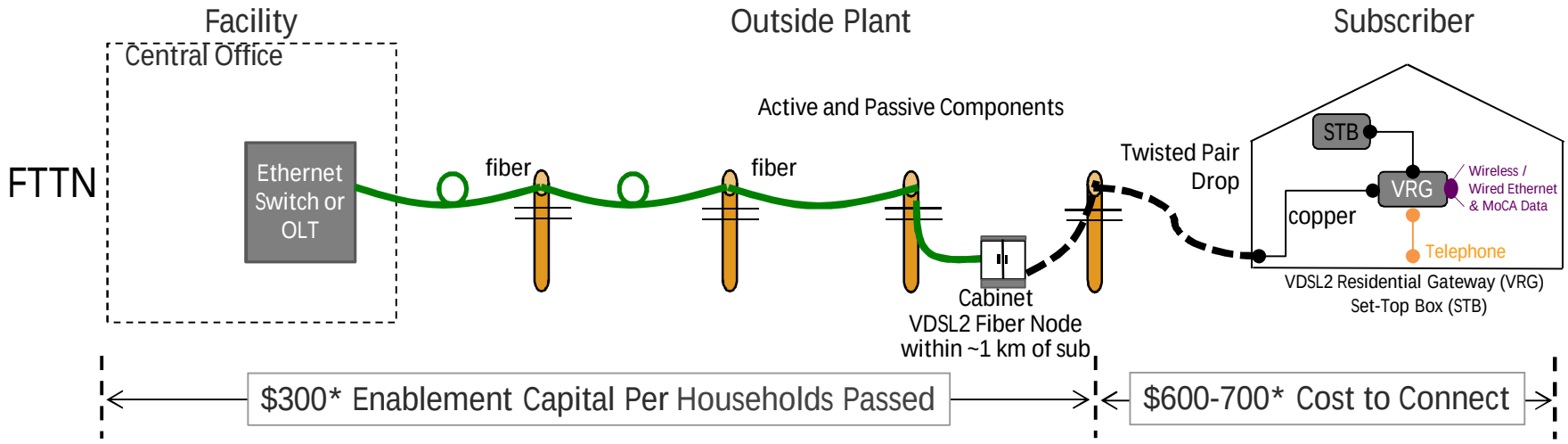
Wireline Access Network Evolution



Telco

Network Migration Assessment

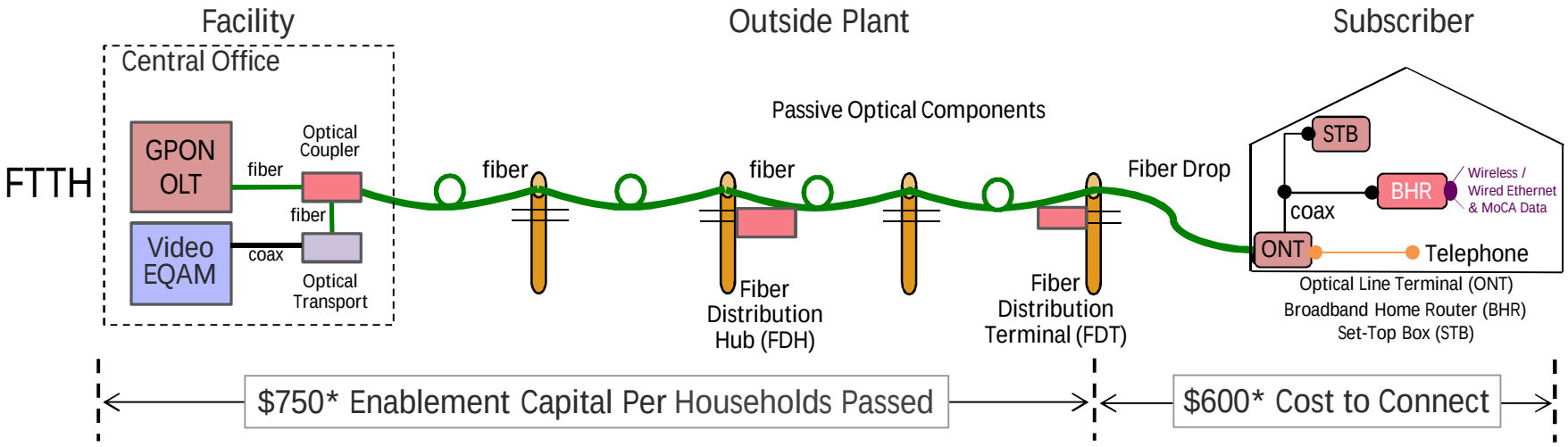
AT&T U-verse®
Fiber to the Node w/ VDSL2 & Preexisting Copper



	Enablement Capital (Cost to Pass a Home)		Success Capital (Cost to Connect a Home)
Capital Components	• Ethernet Switch, Optical Tx/Rx, plus Video Equip not shown • Install video multicast capable nodes • Labor Costs	• Optical Cable, Construction, Cabinet and Installation • VDSL2 video multicast capable nodes • We are uncertain if the network equipment at the CO or VDSL2 cabinet is sized for a specified subscriber penetration rate. If it is less than sized for 100% take rate then cost for enablement will increase. In 2008 stated in the low $300 HHP range	• $0 Drop Cable / Labor assumed existing • VDSL2 Residential Gateway (VRG) • IP-STB (assumed 1) • Installation of NID, Gateway, and STB
Variables Impacting Capital	• Cabinet location impacts VDSL2/G.Fast capacity and the closer to serving area greater the cost	• Assumes fiber to within 3000 ft. (1 km) of the VDSL node subs • Amount of aerial versus underground is a major factor • Distance between Cabinet and Customer impact capacity • Labor Cost and Methods Vary regionally and over time can be +/-	• Additional Set-top boxes will increase cost to connect • Material and Equipment Costs Vary • Variable Installation Time and Labor Rates

Fibre Investment and Policy Challenges, OECD Workshop, Stavanger, Norway 10-April-08, Richard N. Clarke, Assistant Vice President, AT&T - Public Policy, Page 17
http://www.oecd.org/sti/broadband/40460750.pdf

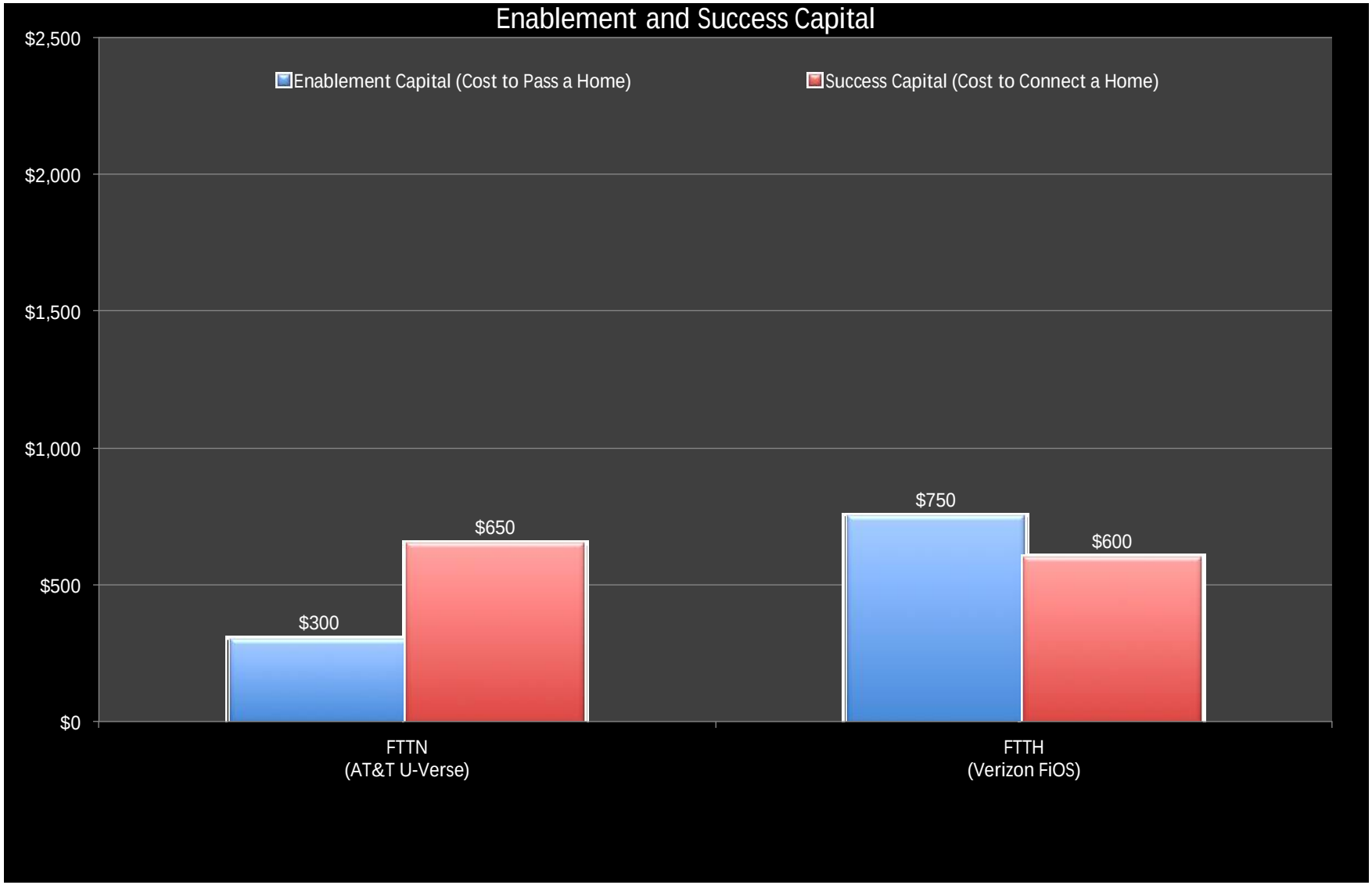
Verizon FiOS®
Fiber to the Home (FTTH) with GPON



	Enablement Capital (Cost to Pass a Home)		Success Capital (Cost to Connect a Home)
Capital Components	• GPON OLT, EMS, Passives, Racks, Cabling, power, and Labor Costs • GPON OLT may be sized for a specific sub take rate and cost could rise	• Fiber Optical Cable Costs • Distribution Hubs, Terminal, Passives, Connectors • Construction and Installation Labor • It is not know the sizing of the Fiber Distribution Hub or Splitter Hub this may not be sized for 100% take rate or even 50% this would increase enablement capital per HHP to add subscribers	• Drop Fiber and Labor Costs • Optical Network Terminal (ONT) • Broadband Home Router (BHR) • Digital Cable STB with MoCA (assumed 1) • Installation of ONT, BHR, and STB Costs
Variables Impacting Capital	• OLT spending as part of HHP enablement CapEx may increase due to take rates and we have no data confirming the OLT sizing.	• Uncertain of the HHP sizing Fiber Distribution Hub or Splitter Hub • Amount of aerial versus underground is a major factor • Home Per Mile is a major factor • Distance between Central Office and Subscriber • Labor Cost and Methods Vary regionally and over time can be +/-	• Additional Set-top boxes will increase Cost to connect • Material and Equipment Costs Vary • Variable Drop Length (unknown) • Variable Installation Time and Labor Rates

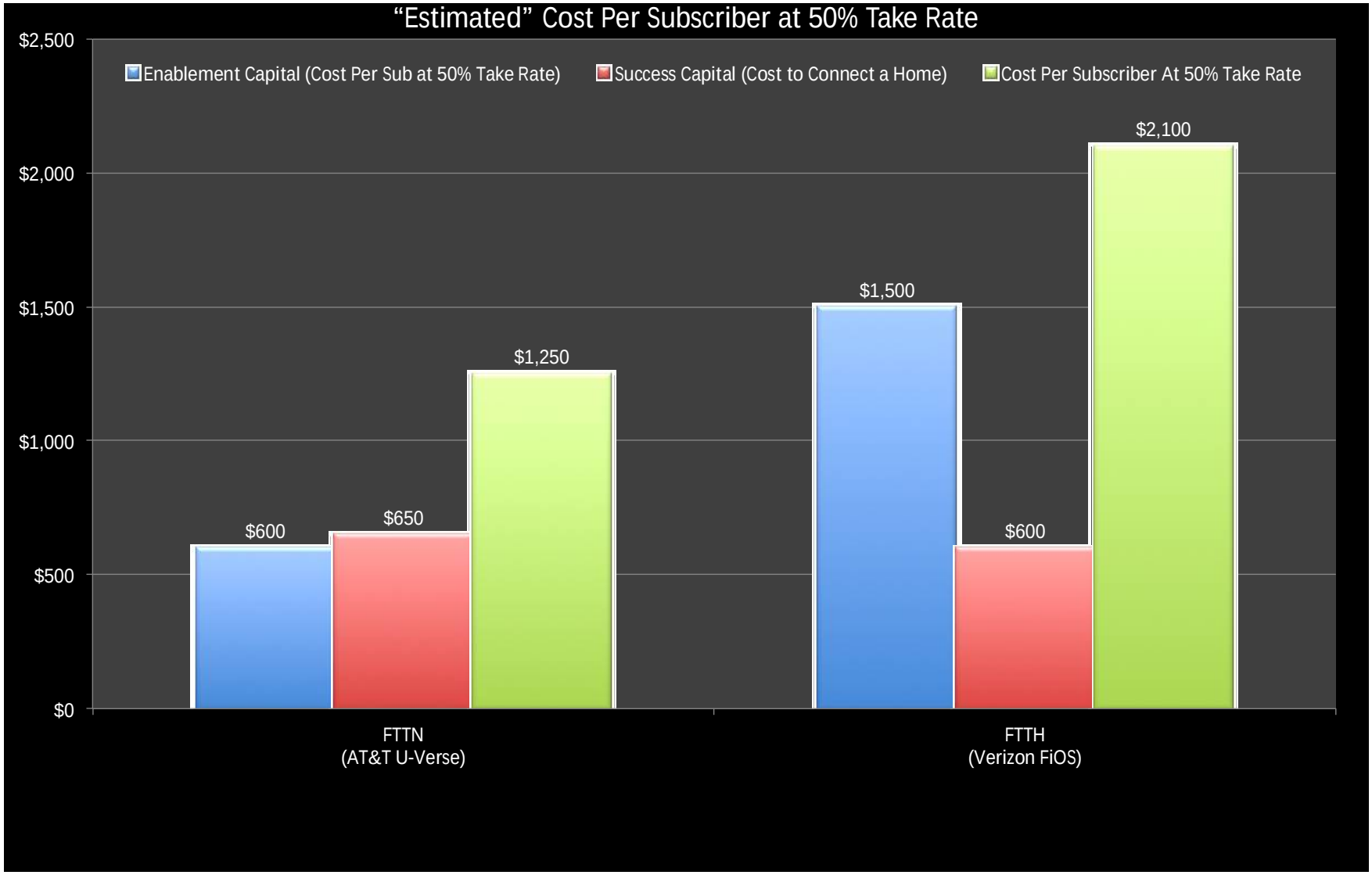
* Verizon FiOS Costs as published by USA Today on March 26, 2010, *"Verizon winds down expensive FiOS expansion"*, Authored By Peter Svensson, Associated Press

Telco Enablement and Success Comparison



Note: FiOS and U-Verse estimates likely allocate a single video set-top box and additional STBs per home would increase Success Capital.

“Estimated” Cost Per Subscriber at 50%Subs



Note: FiOS and U-Verse estimates likely allocate a single video set-top box and additional STBs per home would increase Success Capital

Telcom Future

FTTN - Copper Twisted Pair

- Improvements in signal processing
- Change MAC/PHY (VDSL2 to G.fast)
- Place fiber deeper adding more nodes to shorten loop
- Investing in fiber deep, fewer home per node, & spectrum upgrades
- All in an effort to increase capacity per subscriber
- **Very low enablement capital is major benefit**

Fiber to the Home (FTTH)

- The direction of new build
- GPON has capacity to support triple play
  - video overlay may not be needed resulting less costly IP-STB
- Invest in NGPON2 (10G symmetrical)
- NGPON2 deployments may be targeted where/when needed
- All in an effort to increase capacity per subscriber

Cable Operator

Network Migration Assessment

Cable Operator Network Migration Options

New Build (Greenfield) Moving to FTTH

Existing Network Migration

- Traffic and service tier growth as a result of competition is the main driver!!!
- Paths vary widely within and among MSOs worldwide
- Multiple dwelling unit (MDU) **vs.** single family unit (SFU) may have different paths
- Home densities per mile is a factor for both cost and thus selection of path
- An MSO's view of capital allocation (massive upfront to surgical just in time)

A Range of Migration Options

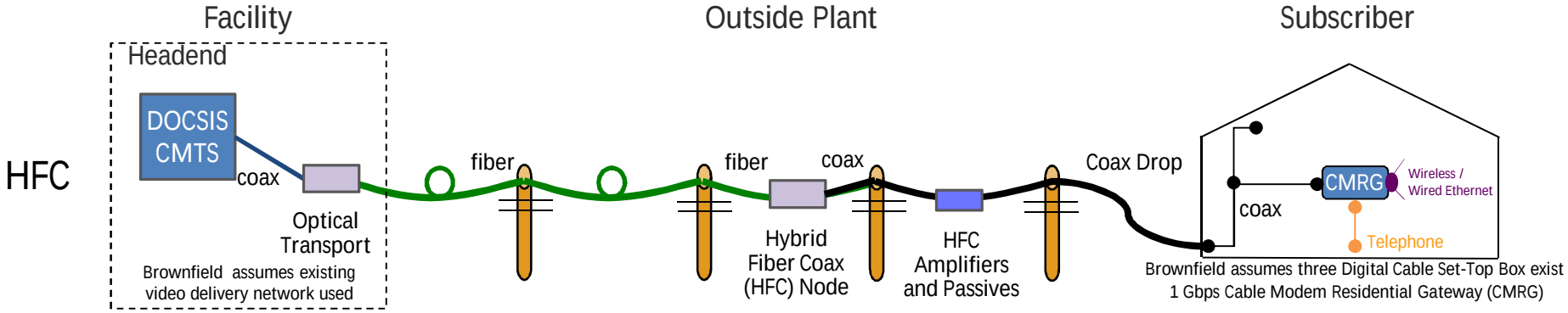
- Optimize the existing network (encoding, b/s/Hz, move to IP/ DOCSIS)
- Business as usual (BAU) node splits and maintain existing spectrum
- Spectrum expansion and change (system upgrade)
- Fiber deep: spectrum expansion & change, deploy fiber for node+0, 30-60 HHP)
- Fiber to the curb (FTTC) "or" last amplifier (FTTLA) "or" fiber to the tap (FTTT)
- Fiber to the home/unit (FTTH/U) using HPON or 10G EPON (or combinations)
- And many many more in between!!!

Use Case Assumptions

- Please read the disclaimer regarding the analysis
- Use cases represent a few migration paths
- Use cases examines a single area assuming:
  - Total plant (miles): **14.1**
  - Total serving Area: **1060 HHP**
  - HFC optical serving area: **530 HHP or 265 HHP**
  - HPON optical serving area: **256 HHP**
  - Homes per mile: **75**
  - Aerial / underground: **100% Aerial**

Cable Operator Preexisting Network Migration

Use Case 1: Today's Existing Network, Spectrum Split, 530 HHP Node and then Add 2.4 Gbps of IP/DOCSIS Capacity



$50* Enablement Capital Per Households Passed

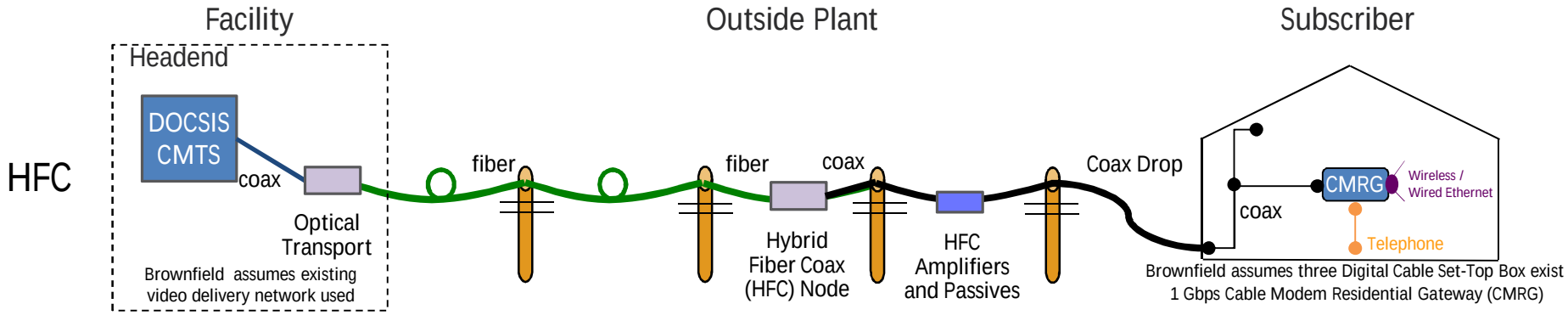
$165* Cost to Connect

	Enablement Capital (Cost to Pass a Home)		Success Capital (Cost to Connect a Home)
Capital Components	• D3.0/3.1 CCAP with 48 SC QAM + 96 MHz D3.1) • Assumes no existing CCAP includes labor and at Infonetics Q4/2014 price per channel ($399.00)	• Assumes Existing Network, Spectrum Split, and 530 HHP Node • Assumed Preexisting: Fiber Optical Cable and Coaxial Cable Costs, HFC Nodes, Coax Amplifiers, Coax Passives, Connectors	• $0 Drop Cable / Labor assumed existing • $0 Digital Cable STB assumed 3 per home • $0 Cable Modem for non 1 Gbps subs • Includes cost for 1 Gbps cable modem residential gateway and installation
Variables Impacting Capital	• Enabling all channels per port and move to D3.1 will likely see lower price per channel & megabit • Excellent cost per sub	• Leveraging existing Outside Plant and Spectrum thus there are no variables to consider on the OSP.	• Material and Equipment Costs Vary • CPE Equipment Type, Selection & Costs • Variable Drop Length (Assumed 150 feet) • Amplifier Equipment needs • Variable Installation Time and Labor Rates

* ARRIS Estimated Capital Cost assumes existing HFC and connections to the subscriber homes with 530 HHP DOCSIS Serving Group sharing 2.4 Gbps of Data (GPON data rate)

Cable Operator Preexisting Network Migration

Use Case 2: Spectrum Upgrade 1 GHz / 85 MHz move from 530 to 265 HHP Node and Add 2.4 Gbps of IP/DOCSIS Capacity per Node



$180* Enablement Capital Per Households Passed

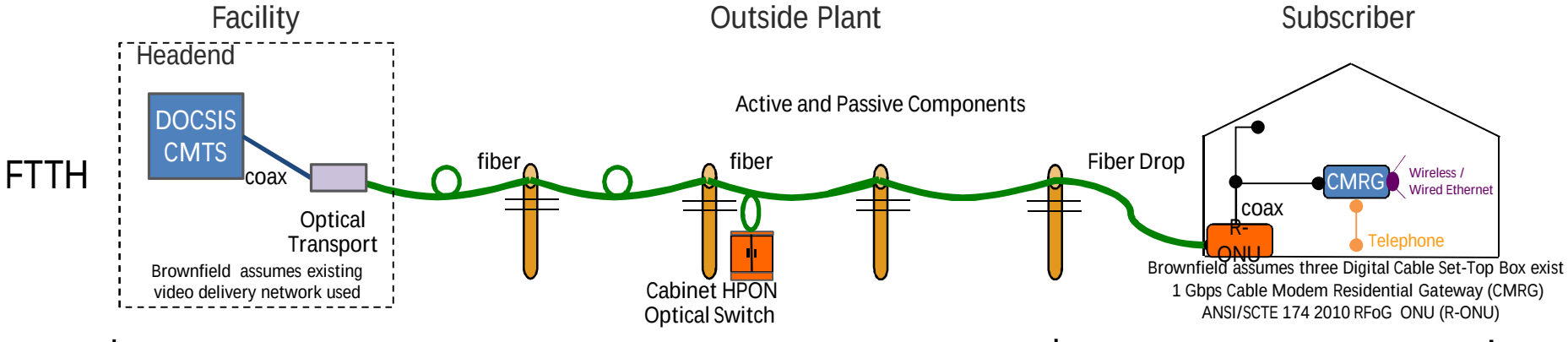
$165* Cost to Connect

	Enablement Capital (Cost to Pass a Home)		Success Capital (Cost to Connect a Home)
Capital Components	• D3.0/3.1 CCAP with 48 SC QAM + 96 MHz D3.1) • Assumes no existing CCAP includes labor and Infonetics Q4/2014 price per channel ($399.00)	• Node Split from 530 HHP physical node to 265 HHP (New Node location is strategically placed to balance the HHP node) • Node Split requires additional enablement capital for optics, nodes, fiber construction & installation labor to new node location. • Spectrum Change means new headend optics and digital receivers as well as upgrading existing amplifiers	• $0 Drop Cable / Labor assumed existing • $0 Digital Cable STB assumed 3 per home • $0 Cable Modem for non 1 Gbps subs • Includes cost for 1 Gbps cable modem residential gateway and installation
Variables Impacting Capital	• Enabling all channels per port and move to D3.1 will likely see lower price per channel & megabit • Excellent cost per sub	• Node Splits cost are impacted by use of aerial vs. underground • An MSO will extend fiber from the current 500 HHP location to the new node location, thus they will not have to run fiber from the HE to the new node location(s) • Labor Cost and Methods Vary regionally and over time can be +/-	• Material and Equipment Costs Vary • CPE Equipment Type, Selection & Costs • Variable Drop Length (Assumed 150 feet) • Amplifier Equipment needs • Variable Installation Time and Labor Rates

* ARRIS Estimated Capital Cost assumes existing HFC and connections to the subscriber homes with 265 HHP DOCSIS Serving Group sharing 2.4 Gbps of Data (GPON data rate)

Cable Operator Preexisting Network Migration

Use Case 3: FTTH using HPON Spectrum 1 GHz / 85 MHz "plus" DOCSIS with 265 HHP Serving Group sharing 2.4 Gbps



$600* Enablement Capital Per Households Passed

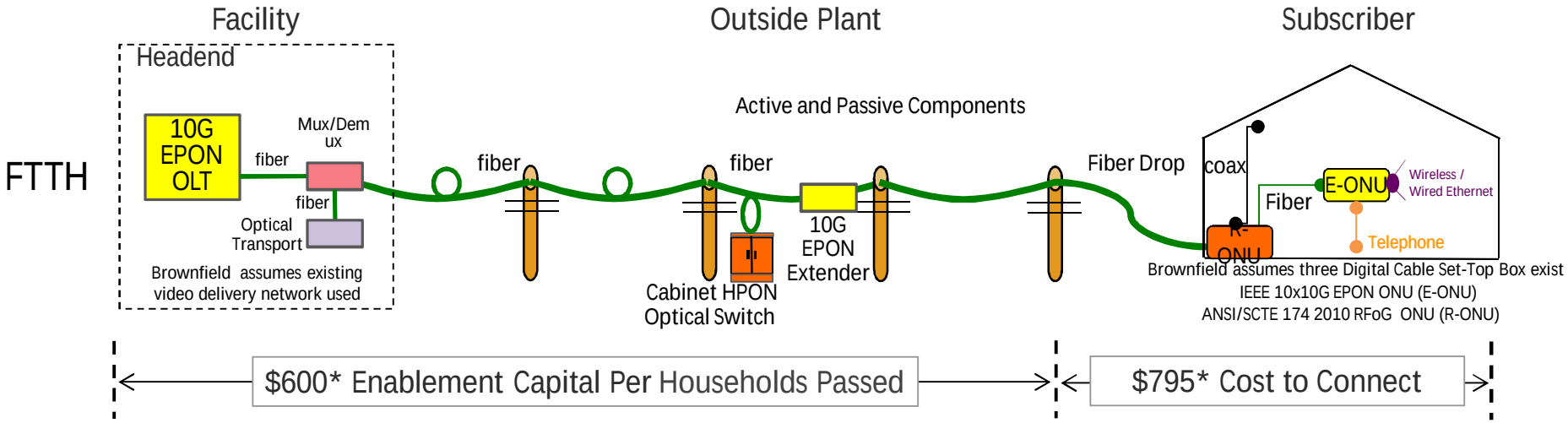
$485* Cost to Connect

	Enablement Capital (Cost to Pass a Home)		Success Capital (Cost to Connect a Home)
Capital Components	• D3.0/3.1 CCAP with 48 SC QAM + 96 MHz D3.1) • Assumes no existing CCAP includes labor and Infonetics Q4/2014 price per channel ($399.00)	• The MSO will not need to run new fiber from the Headend or Hub to the Home, but rather extend the existing fiber at node locations • HPON is sized for 50% take rate upfront though 100% is possible • Assumed a fiber will be pre run to all existing tap location as part of enablement capital, this could be termed as Fiber to the Curb • Running fiber from the tap location to the home is success capital	• $0 Digital Cable STB assumed 3 per home • $0 Cable Modem for non 1 Gbps subs • Includes cost for 1 Gbps cable modem residential gateway and installation • R-ONU and Installation
Variables Impacting Capital	• Enabling all channels per port and move to D3.1 will likely see lower price per channel & megabit • Excellent cost per sub	• Running fiber to all tap locations that may have 4 HHP will put fiber just 150 feet or less away from every subscriber • This assumption place fiber closer than FiOS (64 HHP) but we assume at least 1 customer exists off of each tap and thus justifying this fiber build to the tap location.	• Material and Equipment Costs Vary • Variable Drop Length (Assumed 150 feet) • Variable Installation Time and Labor Rates

* ARRIS Estimated Capital Cost assumes existing HFC, 265 HHP DOCSIS SG sharing 2.4 Gbps, HPON support existing CPE products like Analog, STB, EMTA, and the model assumed a 1 Gbps DOCSIS modem is added but not required if the Customer does not take the 1 Gbps service tier.

Cable Operator Preexisting Network Migration

Use Case 4: FTTH using HPON enabling Legacy Video "and" 10G EPON Symmetrical for All IP based Services

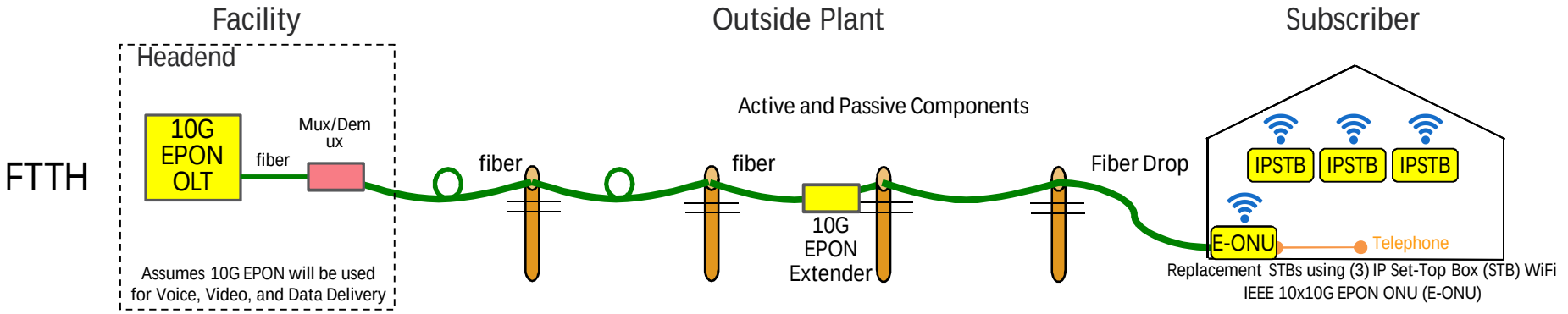


	Enablement Capital (Cost to Pass a Home)		Success Capital (Cost to Connect a Home)
Capital Components	• Includes 10G EPON OLT and will be configured to support PON Extender • Leverage existing DOCSIS back office and video infrastructure	• The MSO will not need to run new fiber from the Headend or Hub to the Home, but rather extend the existing fiber at node locations • EPON is sized for 50% take rate upfront though 100% is possible • Assumed a fiber will be pre run to all existing tap location as part of enablement capital, this could be termed as Fiber to the Curb • Running fiber from the tap location to the home is success capital	• $0 Digital Cable STB assumed 3 per home • Fiber Drop Cable • ANSI/SCTE based RFoG ONU • IEEE based 10 Gbps x 10G ONU • Installation for all components
Variables Impacting Capital	• Leveraging existing Video is an options with Video overlay lambda but will require specialized E-ONU	• Running fiber to all tap locations that may have 4 HHP will put fiber just 150 feet or less away from every subscriber • This assumption place fiber closer than FiOS (64 HHP) but we assume at least 1 customer exists off of each tap and thus justifying this fiber build to the tap location.	• Saves some success capital for leveraging the existing Digital Cable STBs in the home • Material and Equipment Costs Vary • Variable Drop Length (Assumed 150 feet) • Variable Installation Time and Labor Rates

* Estimated Capital Cost assumes 10G Symmetrical, use of DWDM PON Extender for 64 HHP per port, leverage existing MSO video end-to-end enabled by HPON & RFoG.

Cable Operator Preexisting Network Migration

Use Case 5: FTTH using 10G EPON Symmetrical for All IP based Services including Full IPTV Deployment



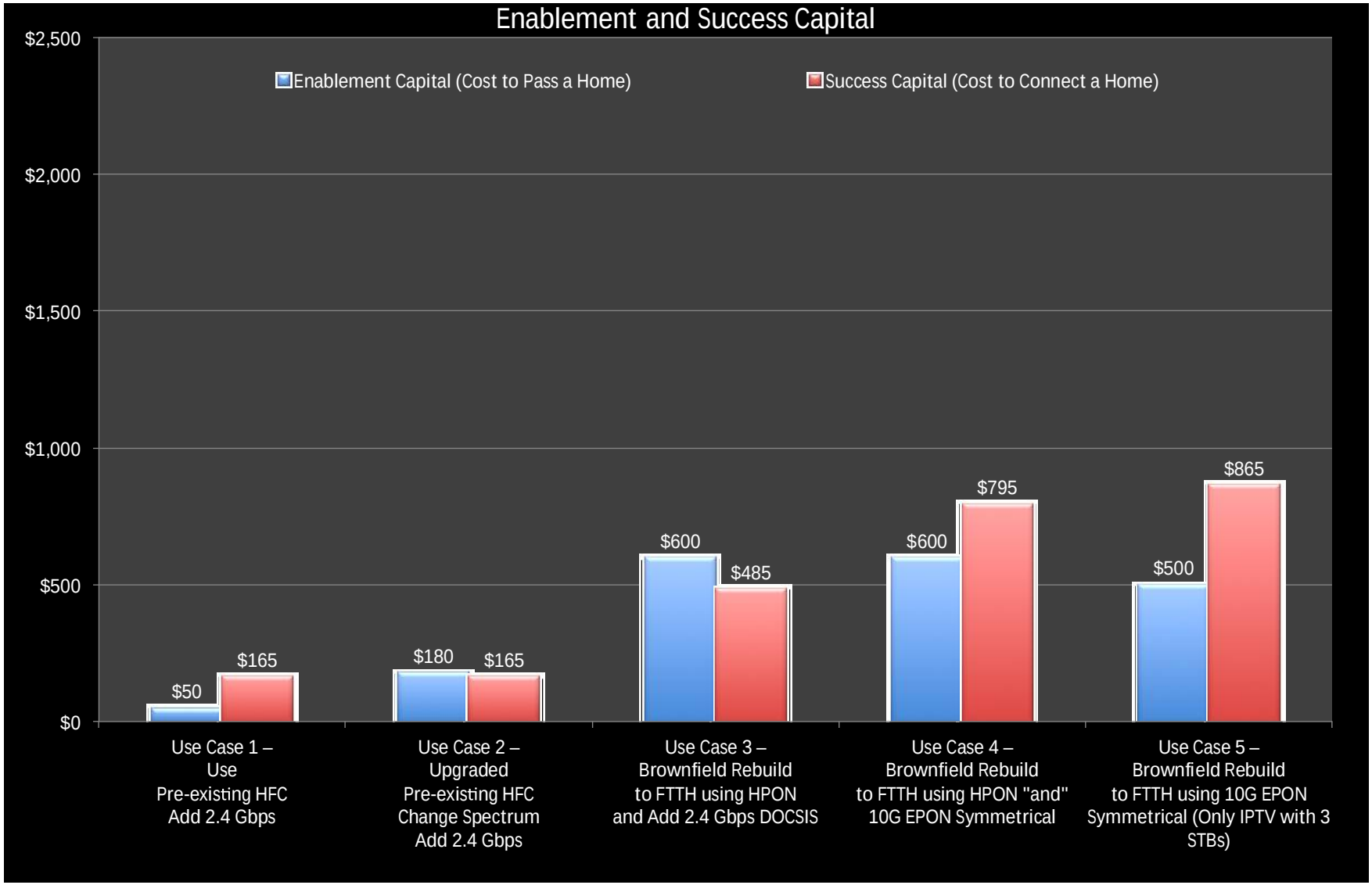
$500* Enablement Capital Per Households Passed

$865* Cost to Connect

	Enablement Capital (Cost to Pass a Home)		Success Capital (Cost to Connect a Home)
Capital Components	• Includes 10G EPON OLT and will be configured to support PON Extender • Leverage existing DOCSIS back office and 10G EPON for IPTV	• The MSO will not need to run new fiber from the Headend or Hub to the Home, but rather extend the existing fiber at node locations • EPON is sized for 50% take rate upfront though 100% is possible • Assumed a fiber will be pre run to all existing tap location as part of enablement capital, this could be termed as Fiber to the Curb • Running fiber from the tap location to the home is success capital	• Replace existing Brownfield three Digital Cable Set-Top Box with 3 IPTV Set-tops Box • Fiber Drop Cable • IEEE based 10 Gbps x 10G ONU • Installation for all components
Variables Impacting Capital	• Assumes All IP video over 10G EPON • Some Video equipment may be repurposed like bulk encryption	• Running fiber to all tap locations that may have 4 HHP will put fiber just 150 feet or less away from every subscriber • This assumption place fiber closer than FiOS (64 HHP) but we assume at least 1 customer exists off of each tap and thus justifying this fiber build to the tap location.	• Migration to IP Set-tops will increase connect costs but reduces if IPSTB in place • Material and Equipment Costs Vary • Variable Drop Length (Assumed 150 feet) • Variable Installation Time and Labor Rates

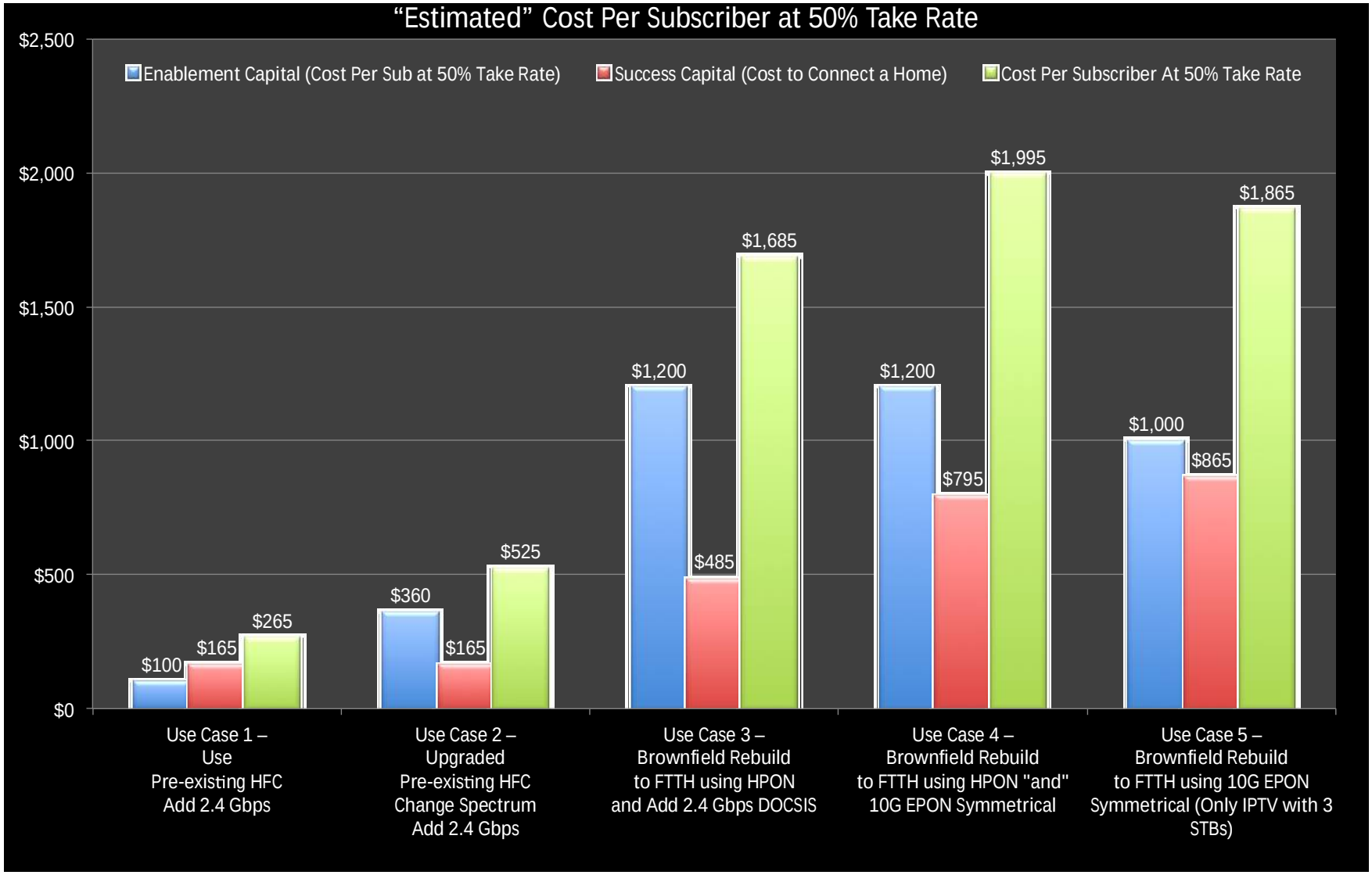
* Estimated Capital Cost assumes 10G Symmetrical, use of DWDM PON Extender for 64 HHP per port, requires IPTV and includes transport of video using 10G EPON

Use Case Enablement & Success Comparison



Note: MSO use cases assume 3 existing Digital Cable Set-tops thus no allocation for STBs except for use case 5 that will require STB replacements to IP-STB

Use Case Cost Per Sub at 50% Take Rate



Note: MSO use cases assume 3 existing Digital Cable Set-tops thus no allocation for STBs except for use case 5 that will require STB replacements to IP-STB

Investment Assessment Summary

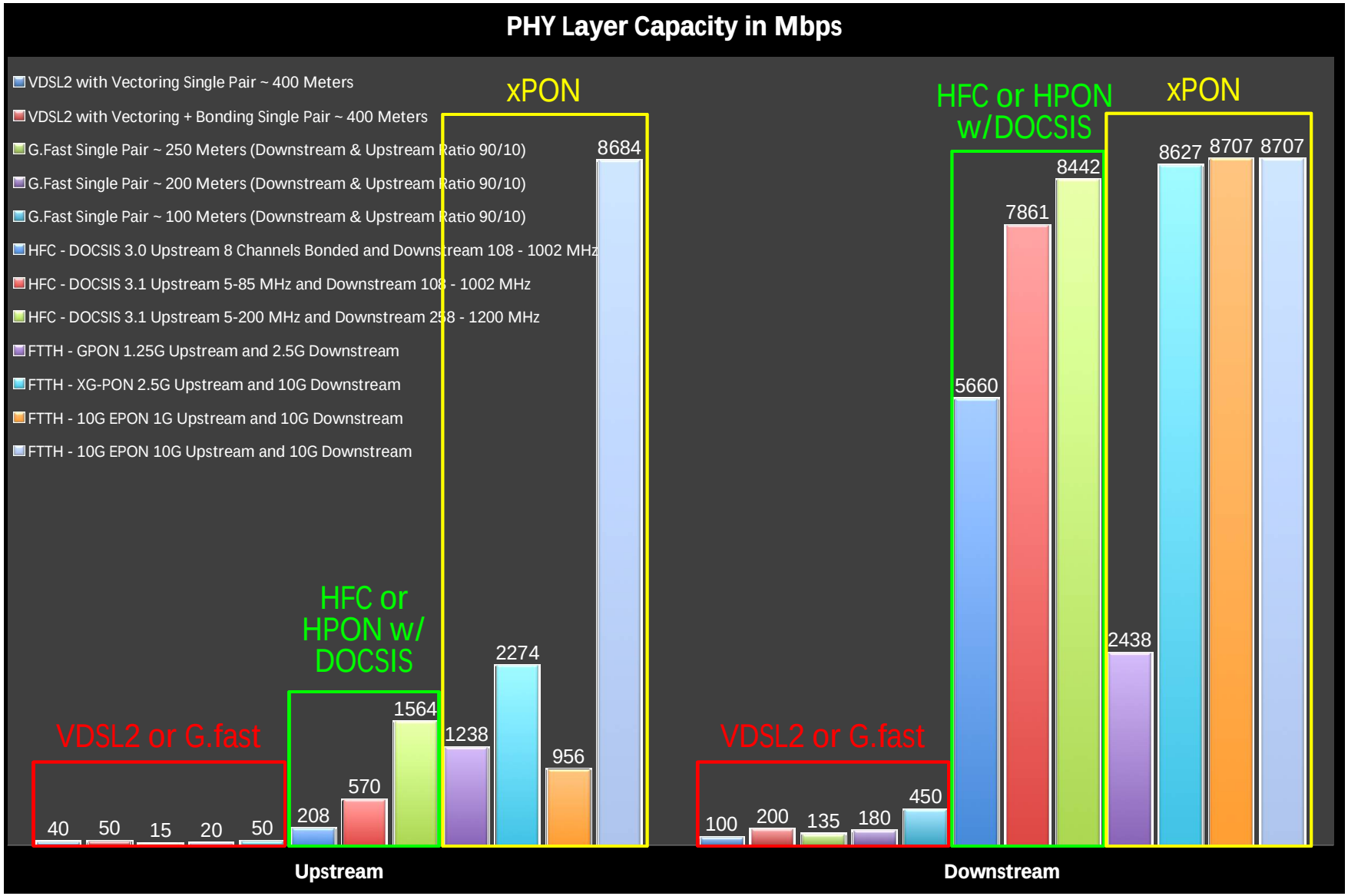
Network Evolution (CTTH)

- Copper/Coax to the home has nearly 100% connects
- Leverage the existing drops twisted pair / coax
- Fastest time to market / minimal impact to neighborhood
- Analysis shows the lowest cost solution
  - Lowest enablement, success capital, & per subscriber cost

Network Revolution (FTTH)

- Substantial overbuilding what exists
- Highest “upfront” enablement, success capital, per subscriber
- Total cost of ownership least understood
- Highest capacity solutions

Access Network PHY Capacities



PHY Layer Rates after encoding and FEC (if used) however the copper solutions are estimate capacity (DOCSIS 3.1 assumes average of 2K QAM Down and 1K QAM Up)

Evolution vs. Revolution Summaries

Evolution – Leverage Existing Copper/Coax Network to the Home

- Evolve and upgrade the data technology MAC/PHY technology
- Upgrade to increase spectrum
  - Telco 1 MHz → 2 MHz → 17 MHz → 30 MHz → 106 MHz → 212 MHz → ???
  - Cable 300 MHz → 550 MHz → 750 MHz → 1000 MHz → 1218 MHz → ???
  - Cable fiber-to-the-tap may permit DOCSIS 1.7 GHz or 4 GHz or 8 GHz
- Invest in building fiber and deploying more nodes/cabinets closer to the subscriber
- Technology upgrades, more spectrum, closer fiber to the homes means more capacity
- Leveraging existing network lowest enablement but requires continued investment
- Enablement and success capital allocation can be surgical where/when needed
- Having an active outside plant likely means higher operational costs compared to PON

Revolution – Overbuild Network with Fiber to the Home (FTTH)

- Heavy upfront investment in enablement and success capital to build FTTH
- Capacity that may last for decades with additional capacity a wavelength away
- Continued data technology investment BPON, GPON, NG-PON2 increases capacity
- All optical and likely all passive optical network means less operation expense

Key Summaries

1. HFC data capacity remains competitive against modern xPON (upstream remains a challenge)
2. HFC serves more homes and customers with far less capital
3. HFC is extremely cost effective when compared any access layer technology
4. Upgrade 1 GHz+ / 85 MHz with 2.5G DOCSIS extremely cost effective
5. Of the FTTH paths 10G EPON has lowest enablement capital
6. Enablement and success cost per bit favors FTTH 10G EPON solutions
7. Cable fiber to the last active or fiber to the tap with HPON leverage CTTH positioning fiber close enabling 10G EPON for selective customers
8. Important factor like operational costs were not considered

Recommendations

Extending the Life of CTTH and preparing for FTTH Transition

- **Consider:**
  - Maximizing existing spectrum, adding more DOCSIS are cost effective choices
  - A spectrum upgrade to 1 GHz or higher when you touch the plant as this will bring the entire network to parity (from CCAP, Optics, Amps, Taps, and CPE)
  - When drop replacements needed, consider Siamese Drop (coax and fiber)
  - Node Splits Drives Fiber deeper in the neighborhood at lower capital costs than FTTH
- **Solves:**
  - Capacity and Service Challenges at far less cost.

Meeting the Extremely High Data Rate Challenge

- **Consider:**
  - This analysis shows the HFC/DOCSIS meeting 1 Gbps+
  - Extremely high downstream, upstream, and even symmetrical services are purchased by a small percentage of subs
  - Building FTTH for those subscribers only
- **Solves:**
  - Billboard Speed Issue
  - Preserves HFC for the masses
  - Pushes fiber closer to the subscriber.

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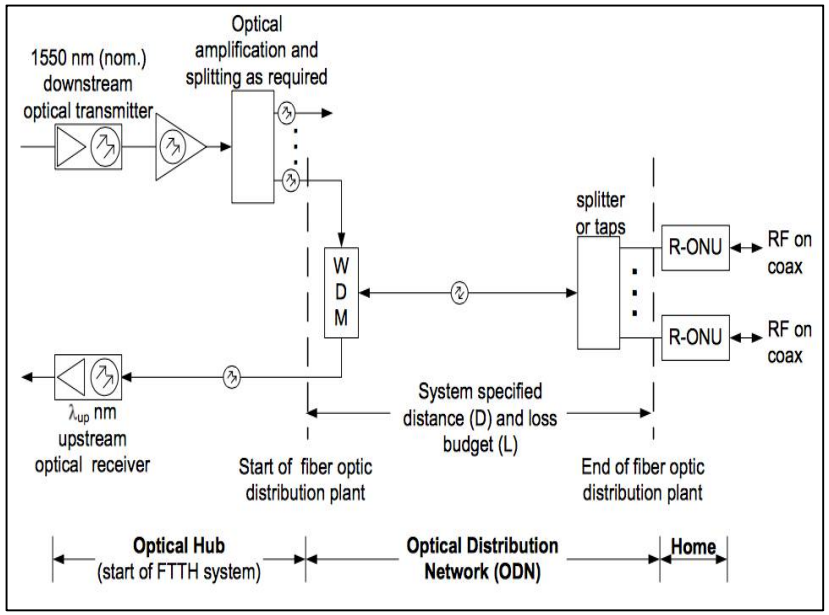
Appendix

Introduction of HPON
Hybrid Passive Optical Network

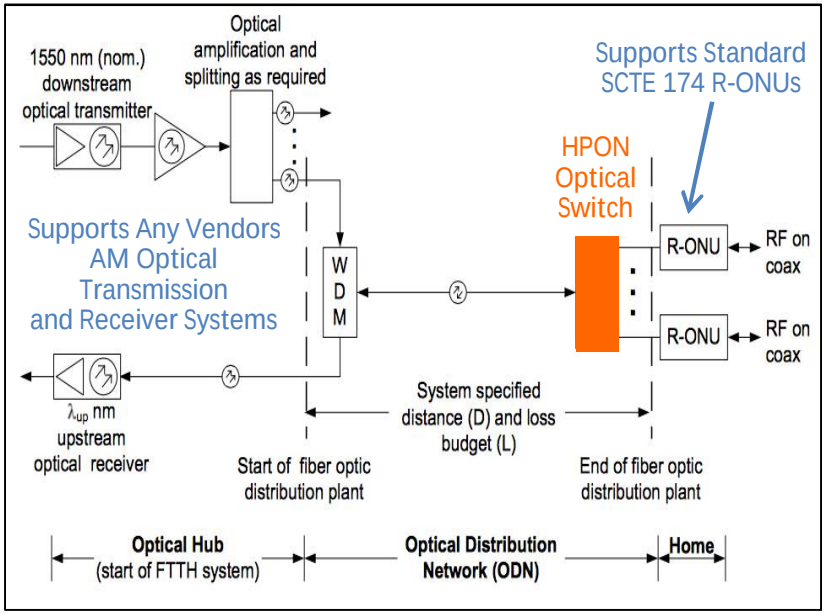
Fiber to the Home (FTTH) using Hybrid – PON (1 of 3)

RFoG Reference Architecture (ANSI/SCTE 174 2010)



- **SCTE RFoG may use a Passive Optical Network (no electronics) or may use an Active Optical Network (use of active electronics in the ODN)**
- **RFoG Drivers for Actives (electronics) in the ODN include:**
  - Extends optical reach from 20 to 60 km
  - Convert the RFoG upstream RF signals from analog to Digital Return
  - Use of WDM to maximize the number of RFoG PON Service Groups

HPON Reference Architecture



- **HPON uses an Active Optical Network (use of active electronics in the ODN)**
- **HPON Drivers include:**
  - Prevention of Optical Beat Interference (OBI)
  - Extend optical reach Long Reach and Large Splits
  - Up to 40 km and 1024 Splits today, more possible tomorrow
  - Fiber to the Curb/Deep HFC for CTTH
  - FTTH solutions leveraging existing MSO systems

Fiber to the Home (FTTH) using Hybrid – PON (2 of 3)

Definition of HPON:

- HPON technology prevents from happening a major problem found in RFoG known as optical beat interference (OBI)
- Prevents OBI with the addition of an active in the Optical Distribution Network (ODN), this active is called HPON Optical Switch
- Implements optical collision avoidance (OCA) to prevent OBI completely
- The combination of the HPON Optical Switch and star physical topology prevents OBI
- Supports fully backward compatible with ANSI/SCTE 174 2010 RFoG equipment deployed at both the home and headend
- Supports any ANSI/SCTE 174 2010 RFoG ONU (R-ONU) and amplitude modulated (AM) headend optical transmitters and receivers
- Transport any RF signal, such as Analog Video, Digital Video, DOCSIS SC-QAM, DOCSIS OFDM, and future RF technologies
- Is a Media Conversation PON technologies (like RFoG) and these are unlike Data PON technologies (e.g. GPON and EPON)
- Data PON technologies use MAC and PHY layers to manage multiple access communications to preventing optical collision

How HPON Works:

- HPON is a Media Conversation PON technologies (like RFoG) and unlike Data PON technologies (e.g. GPON and EPON)
- Media Conversion PON Technology performing only Optical-to-Electrical or Electrical-to-Optical conversion
- Source RF signals are placed into RFoG devices where media conversion between the coaxial and fiber network is performed
- RF carrier is received at the AM optical transmitters with linearly varying voltage input signal (modulating) directly translates into a corresponding light intensity (optical power) of the laser for optical transmission.
- Upstream processing may vary by implementation to avoid optical collision between multiple user
- Media Conversion PONs operate independent of the RF Data MAC and PHY layer (e.g. DOCSIS), thus the optical domain is unmanaged
- Data PON technologies define an optical MAC and PHY layer to managed multiple access system communications (avoiding optical collisions)

Fiber to the Home (FTTH) using Hybrid – PON (3 of 3)

Architecture of HPON

- HPON is a point to multipoint fiber-to-the-home system optimized for compatibility with hybrid fiber-coax (HFC) networks
- HPON prevents OBI with the addition of an active network element in the Optical Distribution Network (ODN), this active is called HPON Optical Switch
- The combination of the HPON Optical Switch and star physical topology to the R-ONUs prevents collisions in the optical domain or OBI
- HPON optical switch can be placed in existing RFoG deployments to prevent OBI
- The HPON Optical Switch will likely be at the location in the ODN where typically an optical splitter would have been located
- Cable operators may select HPON Optical Switch that may also support non-RFoG functions, like EPON Extender, EPON pass-thru, analog to digital optics, etc.

HPON Reference Architecture