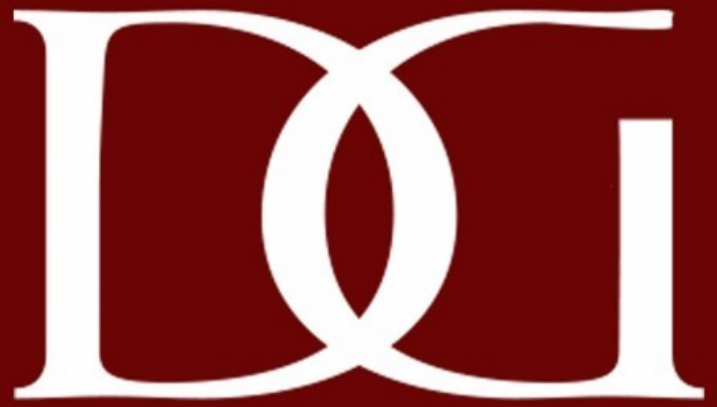

DELL'ORO GROUP INC™

State of Broadband in North America

January, 2023

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Dell'Oro Group

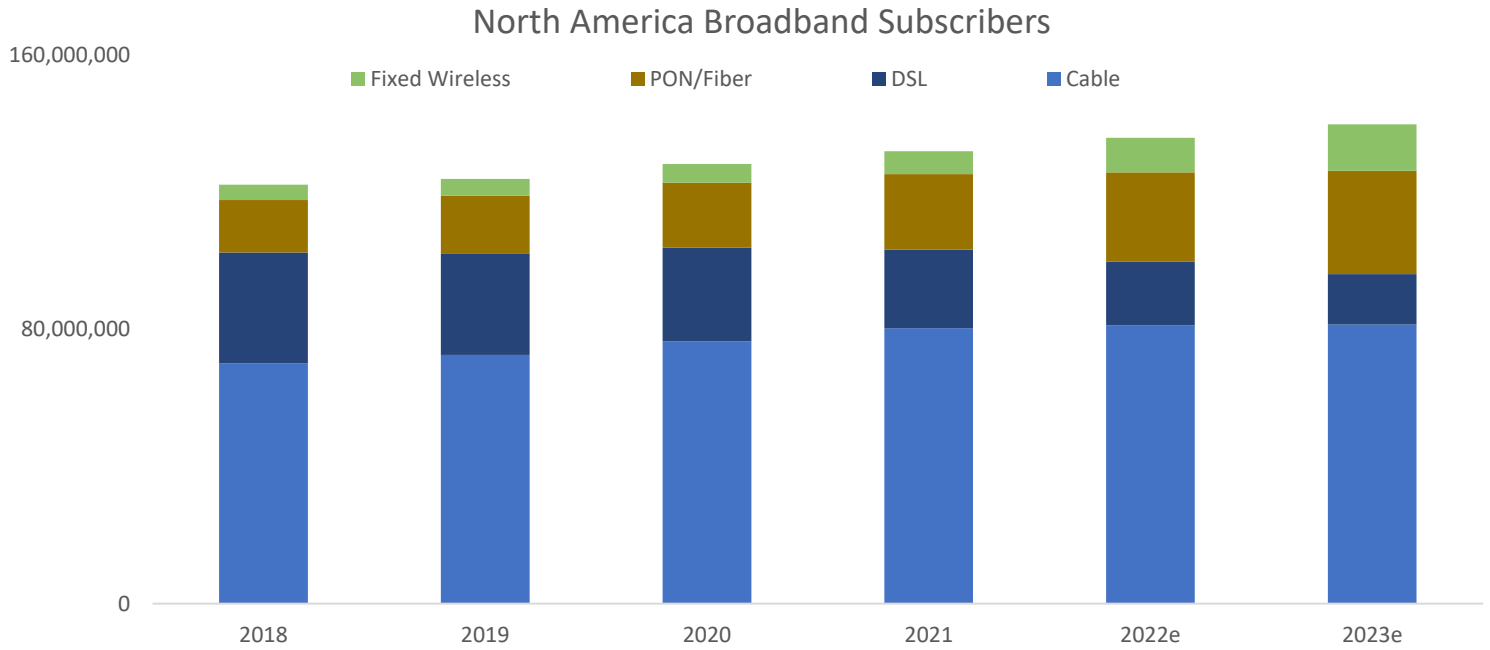
Agenda

- ❑ Overall North American Trends and Drivers
- ❑ Current Spending Levels and Forecasts
- ❑ PON and Fiber Deployment Trends
- ❑ Cable Equipment Market and Trends
- ❑ Fixed Wireless Equipment Market and Trends
- ❑ Broadband's Future

Characterizing the Broadband Market

- Broadband remains a key investment focus for operators
- Current spending cycle expected to last through 2026
  - Previously thought peak would be in 2024. But supply chain, labor constraints will extend fiber, DOCSIS 4.0 buildouts. Subsidy efforts will be extended.
- This cycle will be sustained by increasing competition, land grabs, and further government subsidization
  - Fixed wireless on the lower end of competition, fiber at the high end
  - Valuations and subsidization are fueling major out-of-market expansion—tremendous amount of overbuilding right now
- Inflation, supply chain constraints, currency fluctuations, new technologies have raised equipment costs

Broadband Subscriber Growth Remains Healthy



- Accelerated growth beginning 2H20 through 2022
- Much of the FWA and fiber growth coming at the expense of legacy DSL

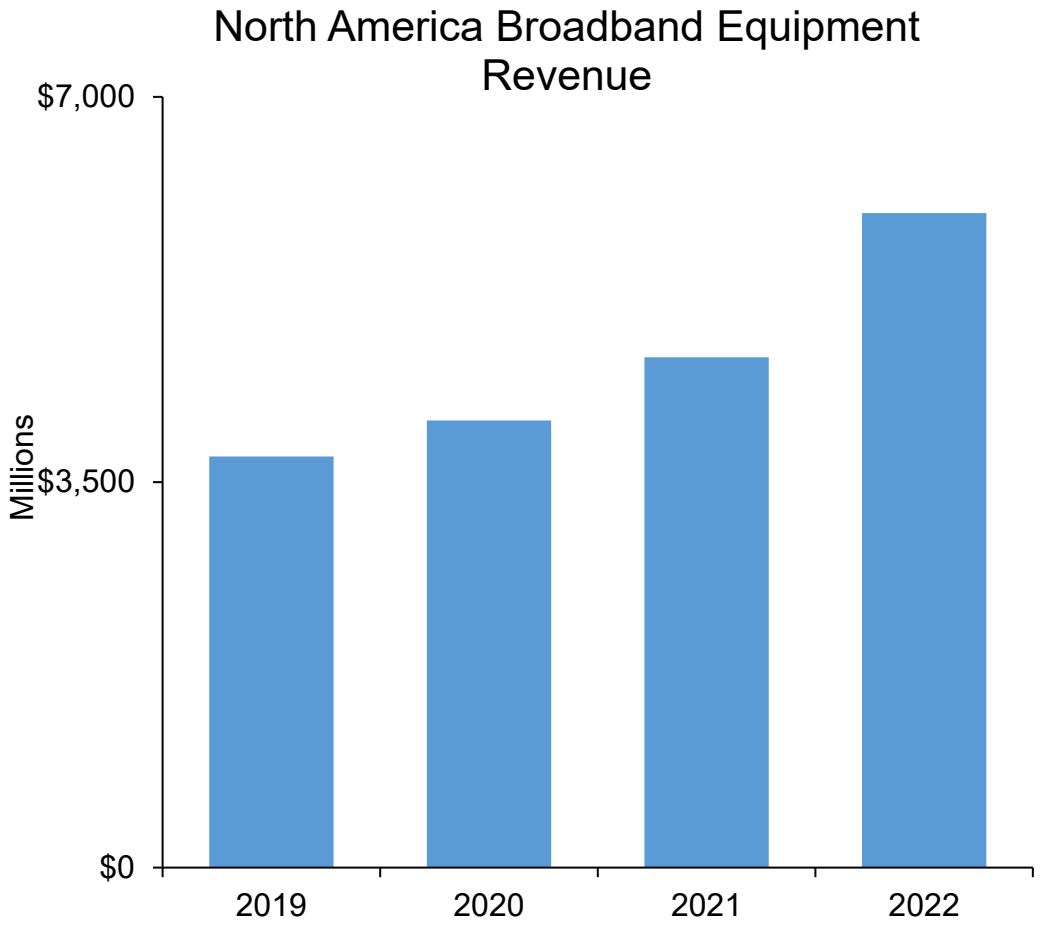
Fiber Commitments Continue to Expand

Fiber Homes Passed	Current	Committed
AT&T	15.5M	30M by 2025
Brightspeed	N/A	3M by 2027
Frontier	3M	10M by 2025
Lumen	2M	12M by 2027
Windstream	1.3M	7M by 2030
Total	~22M	~60M by 2030

- Total of around 90M households expected to be passed by fiber by 2027
  - Up from around 50M today
- FTTH take rates of around 45% expected
- Total subsidies of around $130B through 2030

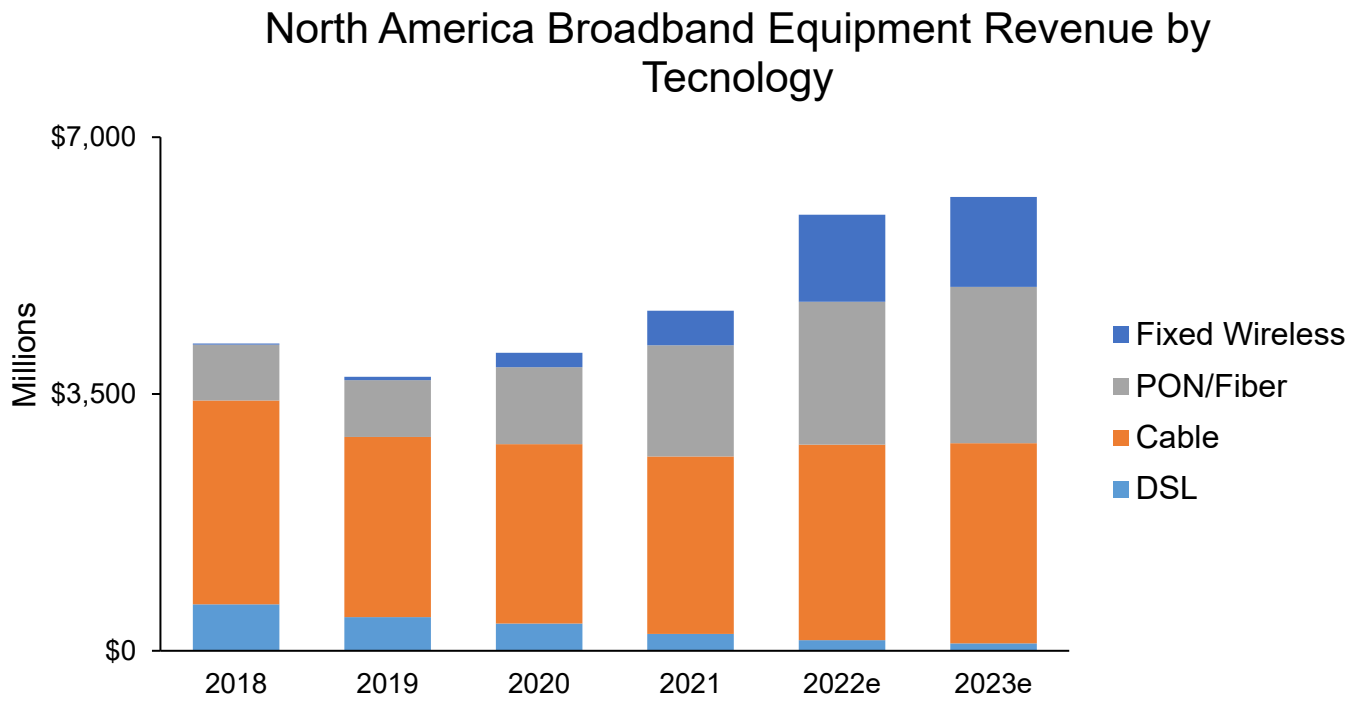
North America Broadband Spending and Forecasts

Infrastructure Spending Remains Robust



- Expected 2022 total revenue of $5.9B
- 28% Y/Y growth from 2021
- 14% Y/Y growth from 2020 to 2021

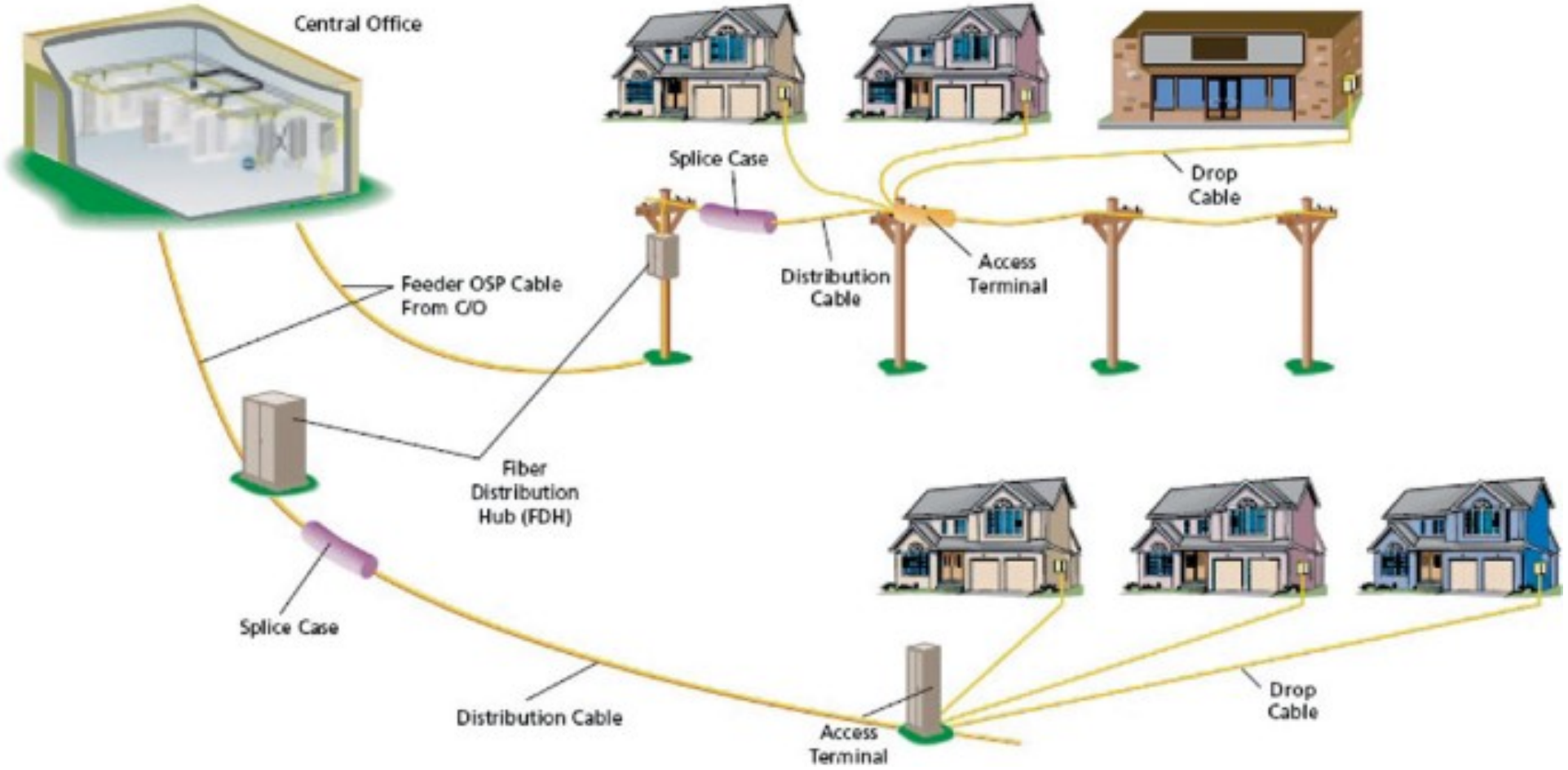
DSL Displacement a Key Investment Theme



- DSL spend drops from $634M in 2018 to just $101M in 2023
  - From 2018-2023, shift of approximately $1.8B in spend from DSL to PON/Fiber
  - Suggests fiber isn't just about expansion, it's also about overbuilding

PON and Fiber Deployment Trends

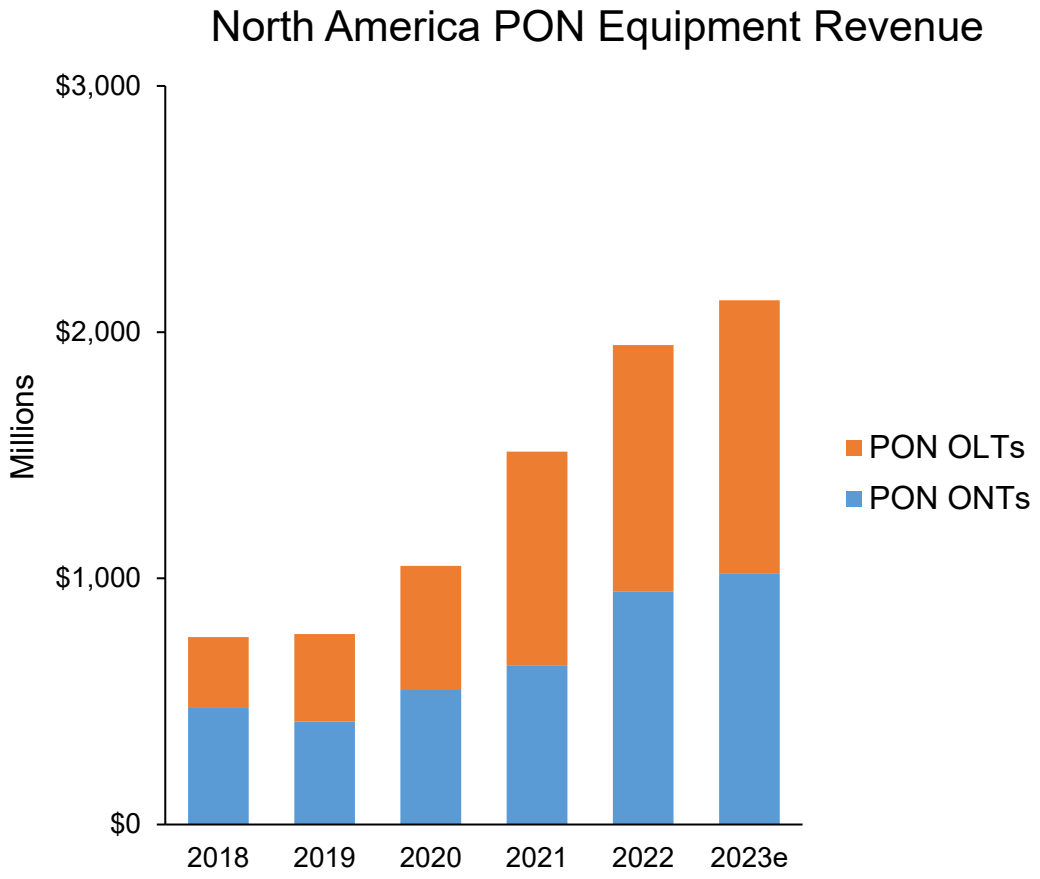
Basic PON Architecture



PON Technologies

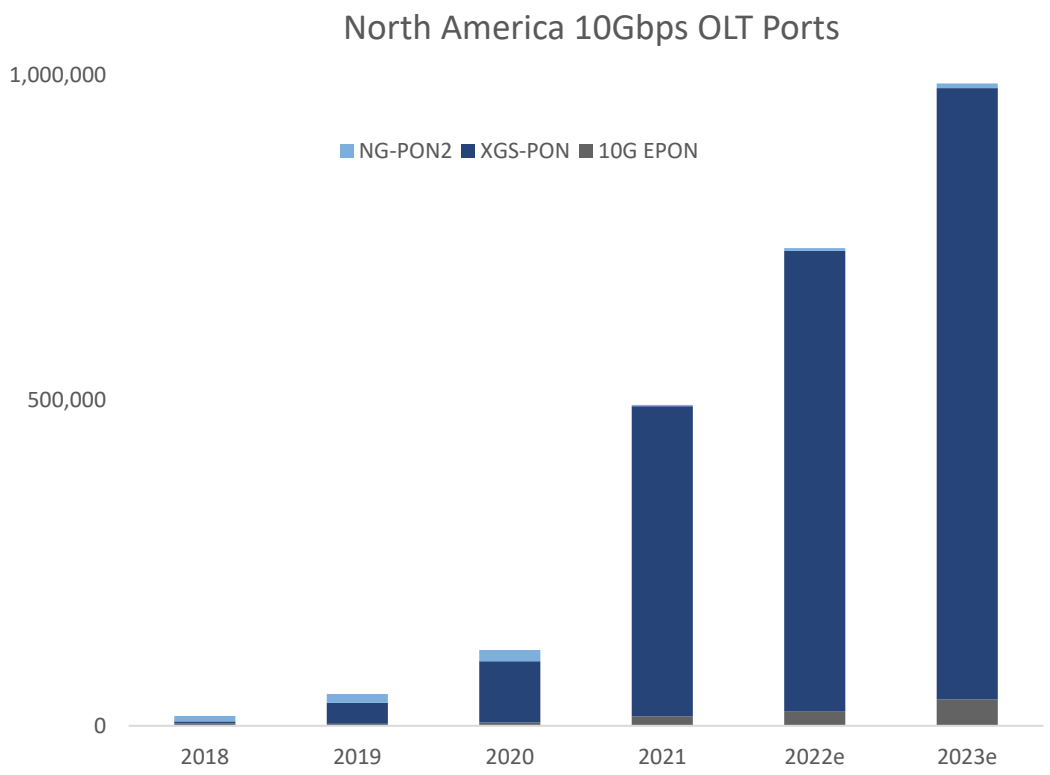
- GPON
  - 2.5Gbps down; 1.25Gbps up
  - Dominant technology in use—Verizon, AT&T, nearly all tier 3s
- XGS-PON
  - Symmetric 10Gbps
  - AT&T, Frontier, others
- 10Gbps EPON
  - Symmetric 10Gbps
  - Cable MSOs

PON Fueling Majority of Total Revenue Growth



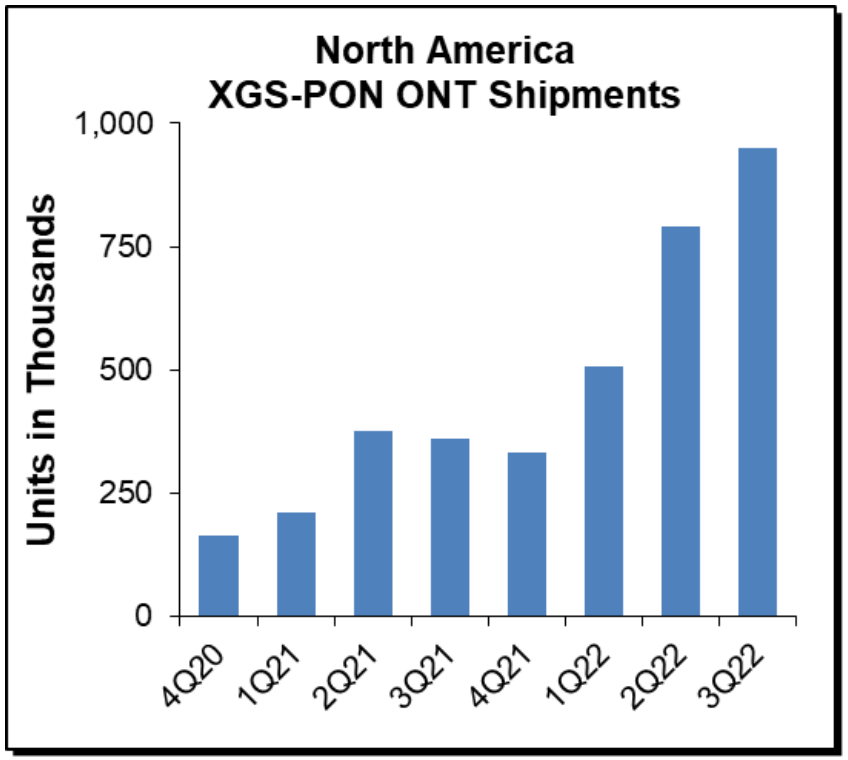
- OLT revenue up 15% in 2022 after 73% growth in 2021
- OLTs less impacted by supply chain issues
- OLT shipments should be up again in 2023; ONTs likely to see slower growth, due to supply chain and slower subscriber growth

All 10Gbps PON Technologies Continue to Ramp



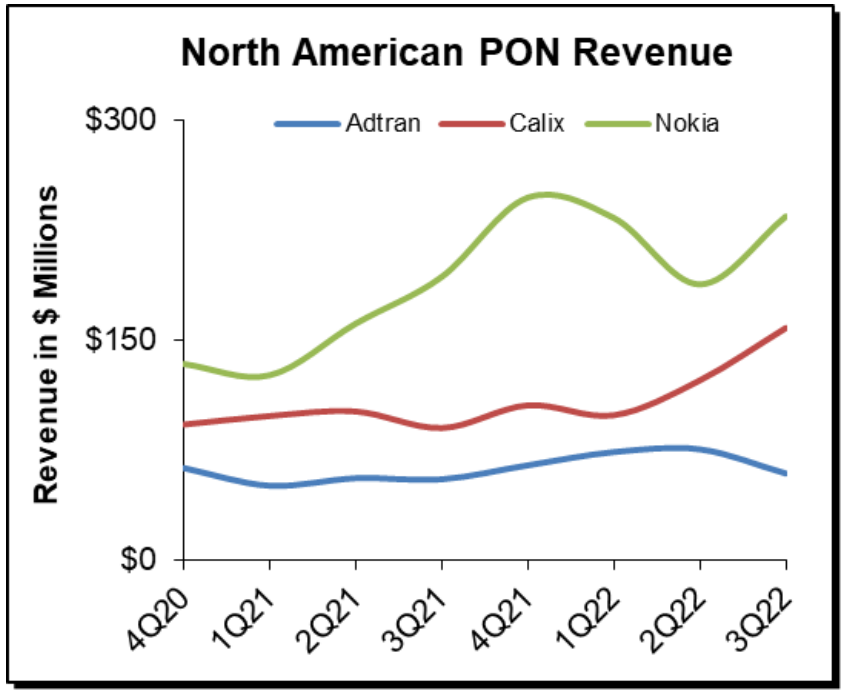
- Frontier, AT&T, tier 3s all deploying XGS-PON
- XGS allows for symmetric 2-5 Gbps services in the future
- 10G EPON back in favor among MSOs
  - Charter RDOF
  - Comcast
  - Easy to integrate with existing DOCSIS management platforms

XGS-PON ONT Shipments Continuing to Ramp



- Units behind infrastructure due to supply chains
- Prices just now beginning to drop as volumes increase
- Units provide either 2.5G or 10G LAN ports for home networking connectivity

PON Revenue Share Trends in North America



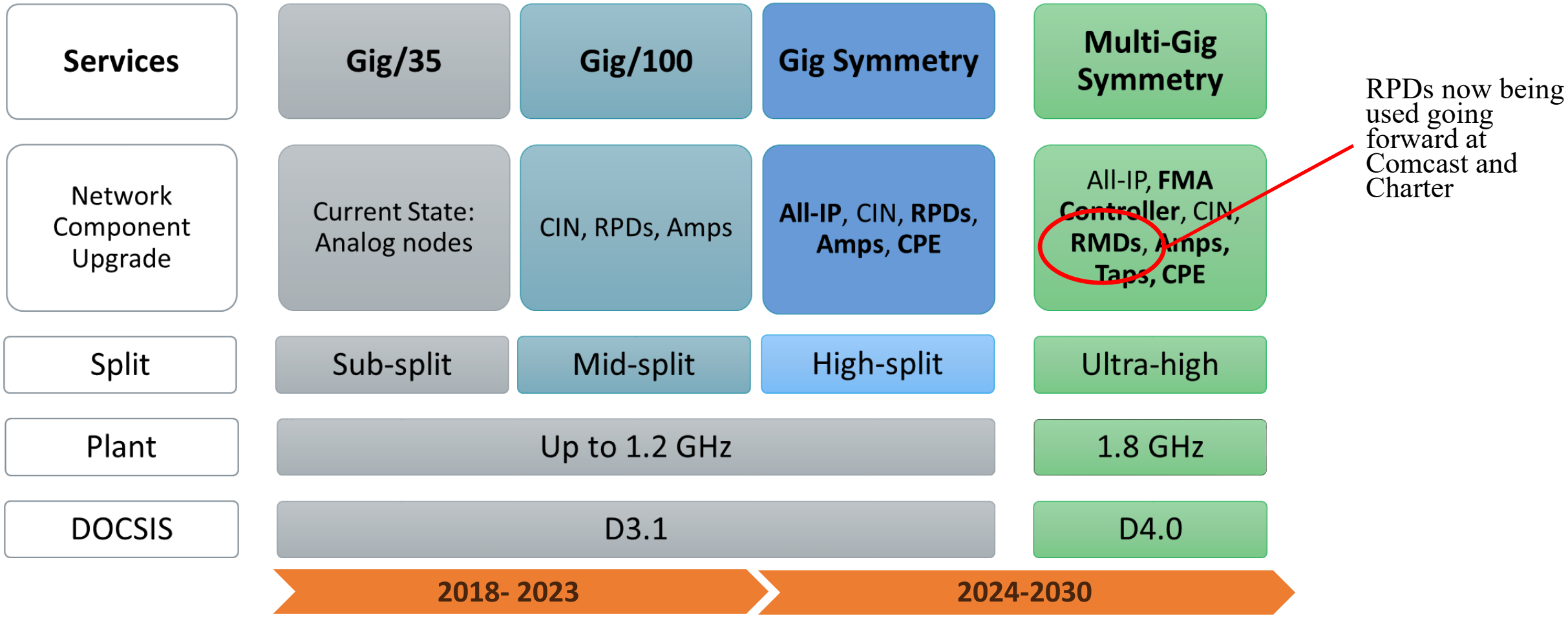
- Nokia's Q3 in NA driven by Frontier and AT&T
- Calix leads among tier 3s—should see continued share gains
- Adtran expanding in North America, and having increasing success in Europe

What's Next for PON and FTTH?

- XGS-PON should dominate through 2030, delivering 1-2 Gbps symmetric speeds
- Nokia XGS can be upgraded to 25GS-PON
  - Can deliver symmetric 5 Gbps services
  - AT&T has already deployed around 30k 25GS-ready OLT ports
- Adtran, others developing 50G PON
- Nokia, CableLabs, and others doing early work on 100G PON

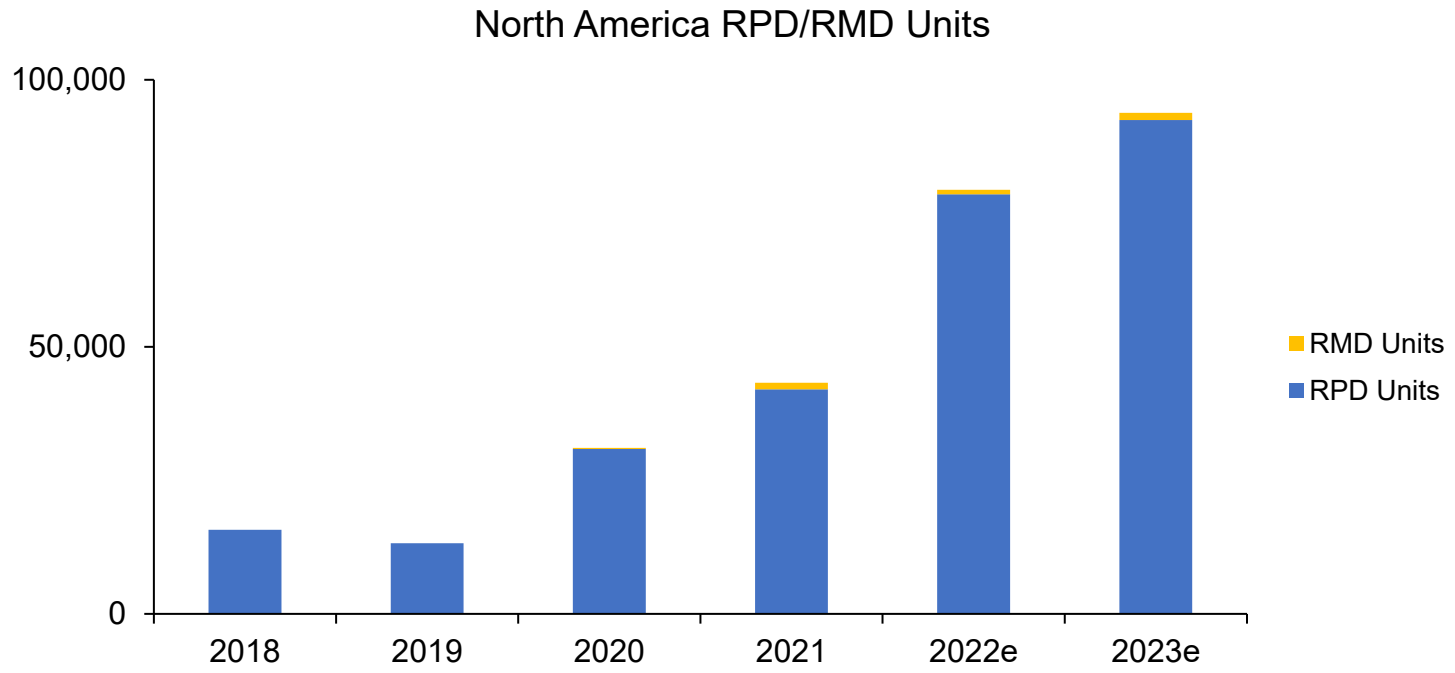
Cable Equipment Market and Trends

Planned Upgrade Path for Larger MSOs



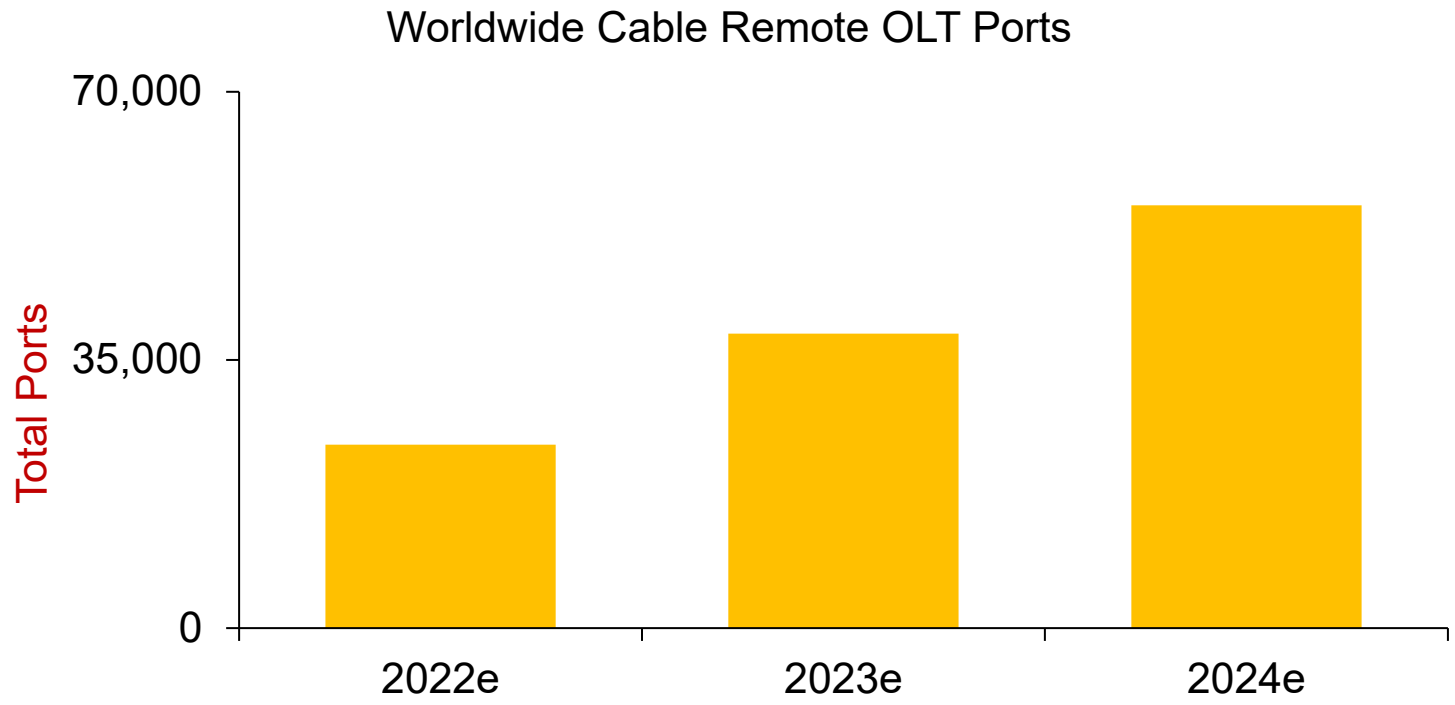
RPDs now being used going forward at Comcast and Charter

MSOs Transforming their Networks through DAA



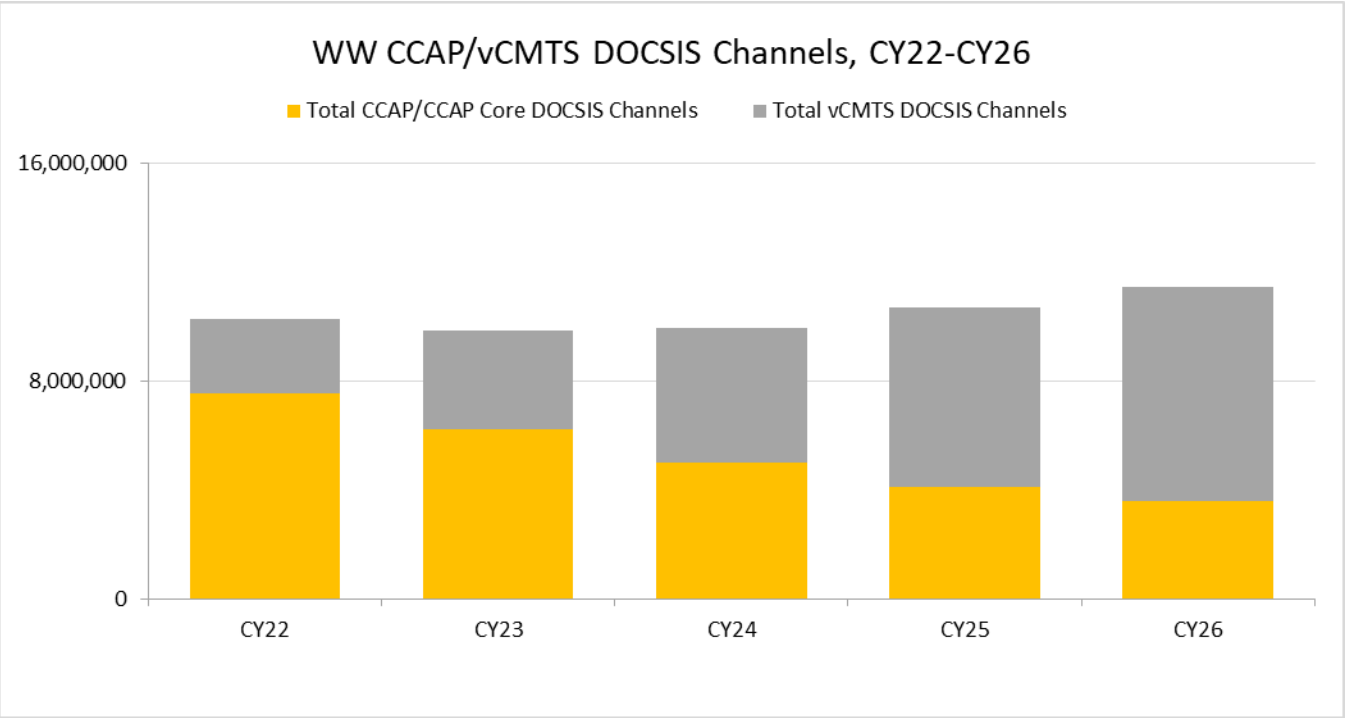
- Replace traditional optical nodes with more layer 2/3 intelligence
- Move from analog optics and transport to Ethernet—improving signal quality and reducing modulation errors

Cable FTTH Deployments also Increasing



- Deployments driven largely by NA tier 1 and 2 operators
- R-OLTs allow MSOs to create FTTH service groups from the same node as cable modem subscribers
- Fiber subscribers can be managed just like cable modem subscribers

vCMTS Deployments will Continue to Expand



- Continued R-PHY deployment growth via D3/1 high-split projects
- Some vCMTS deployments will be tied to R-OLTs for FTTH
- Traditional CCAP with staying power due to traditional node splitting projects

What's Next for Cable Broadband?

- More cable fiber buildouts than previously expected
  - Agreement around R-PHY for DAA also leaves space and power for R-OLT modules to peel off FTTH service groups (Charter RDOF edge-outs are a prime example)
- DOCSIS 4.0 remains a limited to tier 1 operators in North America
  - Primary advantage is cost per home passed: $200/home vs. fiber at $1000+/home
  - Only makes sense now with tier 1 footprints of 5M homes passed or more

Fixed Wireless Equipment Market and Trends

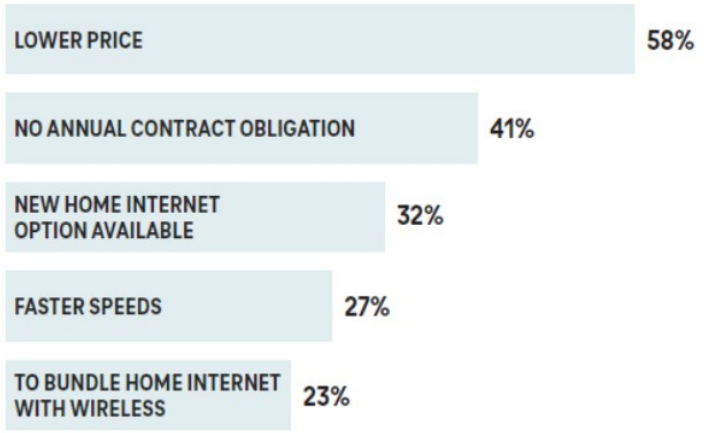
FWA Market Considerations

- FWA is really two separate markets:
  - 3GPP-based technologies using licensed spectrum (T-Mobile, Verizon)
  - Technologies using unlicensed spectrum (WISPs)
- T-Mobile's success has been based on value, churn from existing providers

WHY CUSTOMERS SWITCH

Among the many reasons for switching to 5G Internet, T-Mobile customers list a lower price and no annual contract as leading factors.

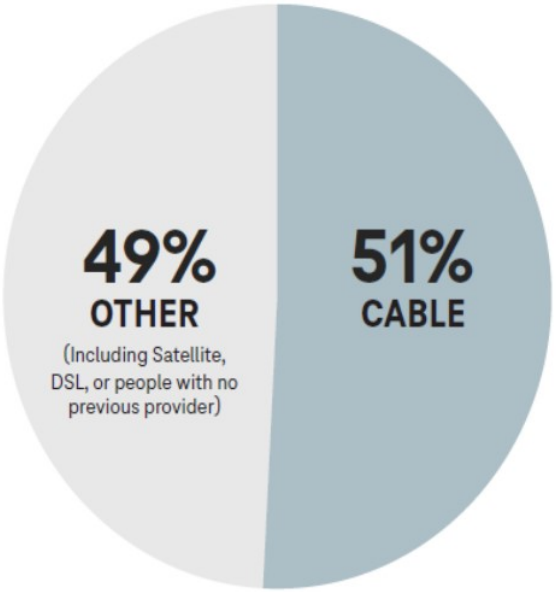
More than a third of customers also listed having a new option as a reason for switching. In 2020, it was reported by the Institute for Local Self-Reliance that more than 80M people only have one choice for home broadband where they live, with more than 45M stuck with Charter or Comcast as their only option. As internet usage continues to increase, fixed wireless services are bringing new choice and competition to these communities.



Sources: T-Mobile, Institute for Local Self-Reliance

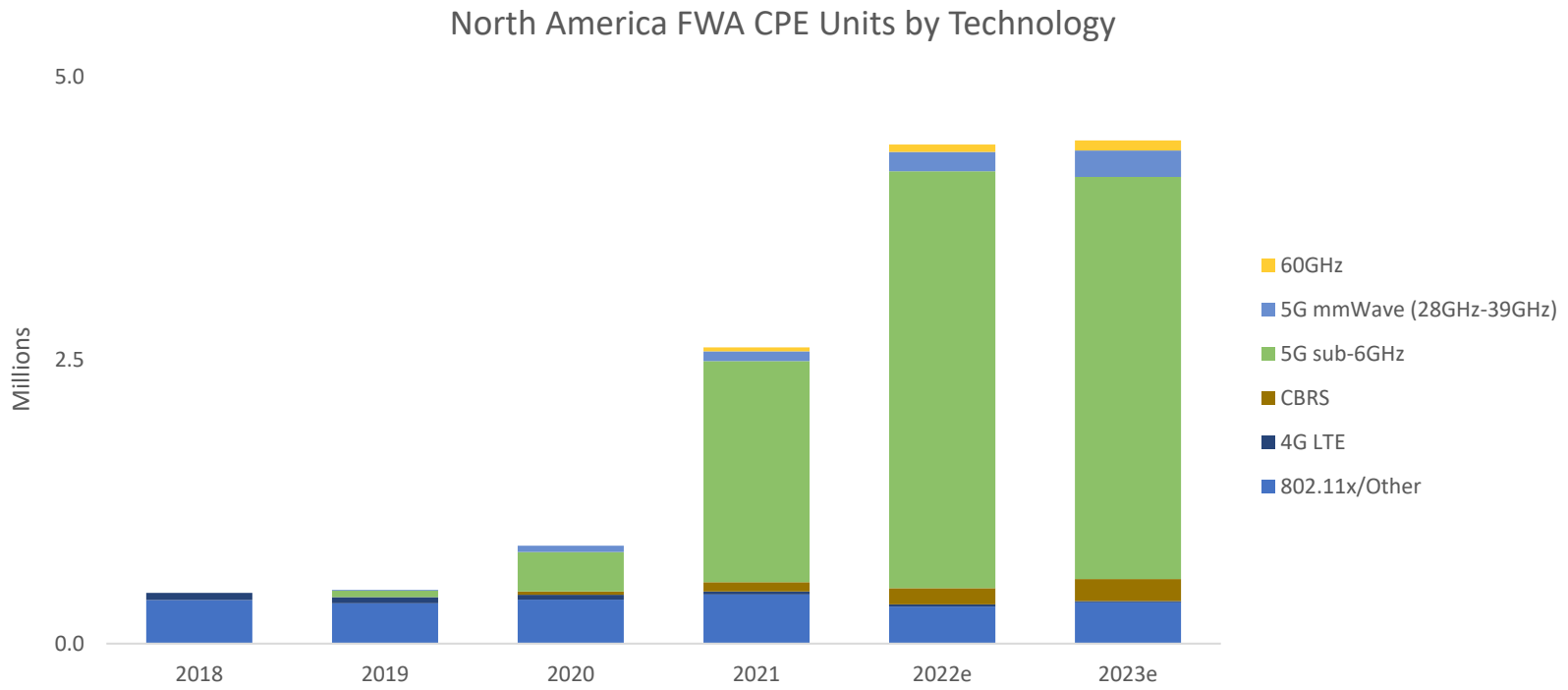
WHERE THEY COME FROM

Customers are leaving cable providers for fixed wireless, and it's clear why. FWA services generally don't require annual contracts, monthly fees or complicated installation. Today, more than half of T-Mobile's 2M+ base of customers are coming from cable.



Source: T-Mobile

5G Sub-6GHz Dominates FWA Deployments



- T-Mobile driving heavy volumes through 2025; Verizon growing sub-6GHz and mmWave units
- WISPs will likely have to get some licensed spectrum to grow
- FWA subscriber growth slows considerably in 2025 and beyond

What's Next for Fixed Wireless?

- Slowing subscriber growth for the entire industry beginning 2025
  - Increased fiber penetration for ISPs
  - Cable operators fight back with DOCSIS 4.0, more flexible plans
- Capacity constraints for T-Mobile as 5G mobile subscribers increase
  - 30M addressable homes across the US
  - Revenue per bit for mobile data is roughly 30x revenue per bit for FWA
  - Verizon allocating more mmWave spectrum for FWA
- WISPs shift more to fiber, use 60GHz for fiber extension

Broadband's Future

- More competition means focus on additional services
  - Bandwidth on demand
  - Managed WiFi, including cybersecurity, cloud storage, parental controls
  - Tiered residential services based on SLAs, latency, etc.
- Post-buildout M&A
  - Some communities/regions will see a fiber glut
  - Additional cable consolidation
  - Potential mobile/cable M&A

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