



# Cable Lifespan Extension with FDX & ESD

Tao Ouyang

Huawei Cable Research Engineer  
[toy.ouyangtao@huawei.com](mailto:toy.ouyangtao@huawei.com)

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## Huawei Achievements & Conclusions

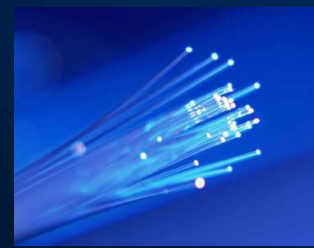
# What's the NEW BRAND for Next Generation Cable?



Wireless

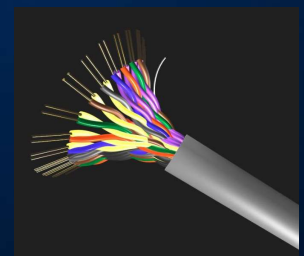


Optical



**50G PON**

Copper



**MG fast**

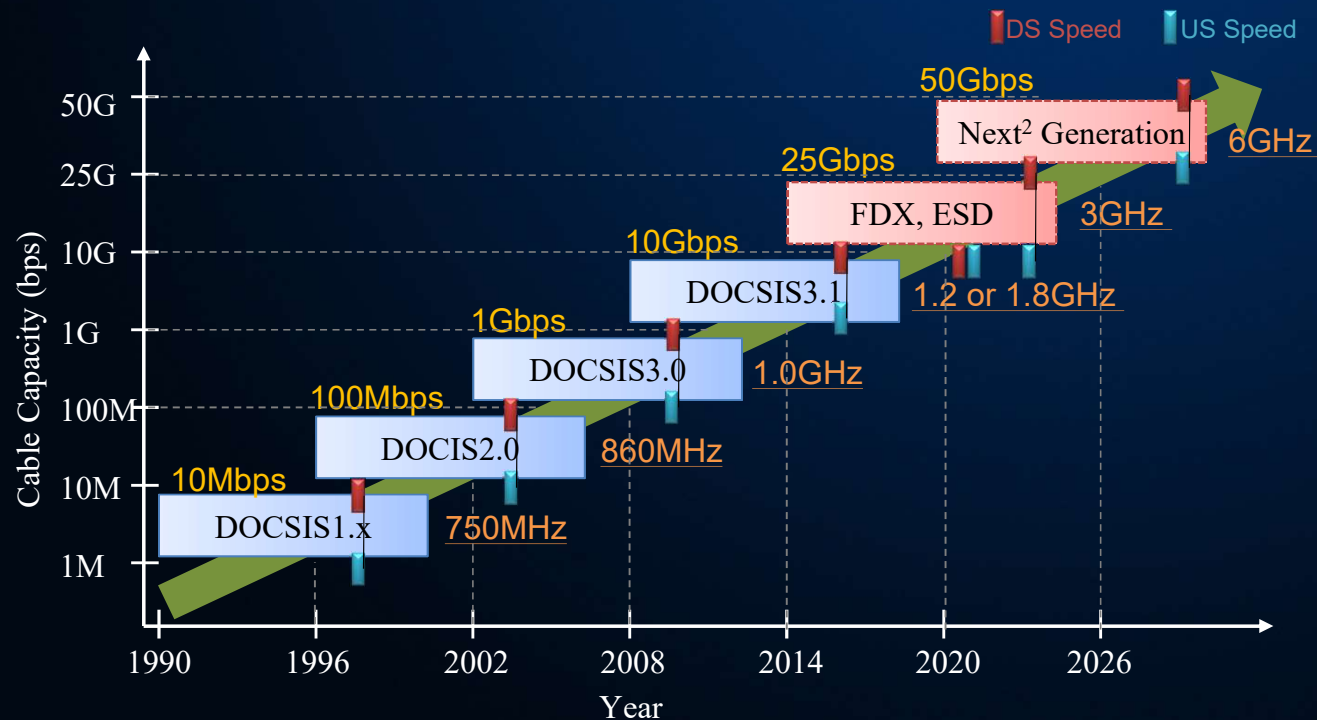
Coax



10G  
25G Cable  
DOCSIS 4.0

?

# DOCSIS Development Tendency Overview



## More Spectrum

- Upstream: 42, 65, 85, 204, 684MHz...
- Downstream: 0.8, 1.0, 1.2, 1.8, 3GHz...

## Higher Efficiency

- SC-QAM to OFDM
- 256QAM to 4K/16K QAM
- RS to LDPC

## More Flexible Duplex

- FDD to FDX

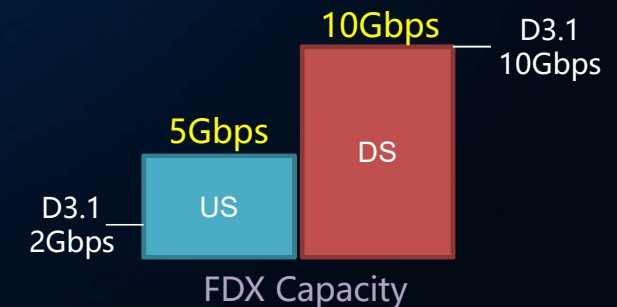
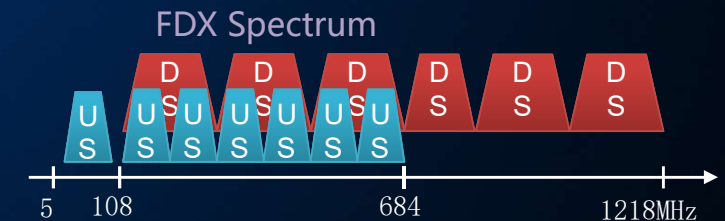
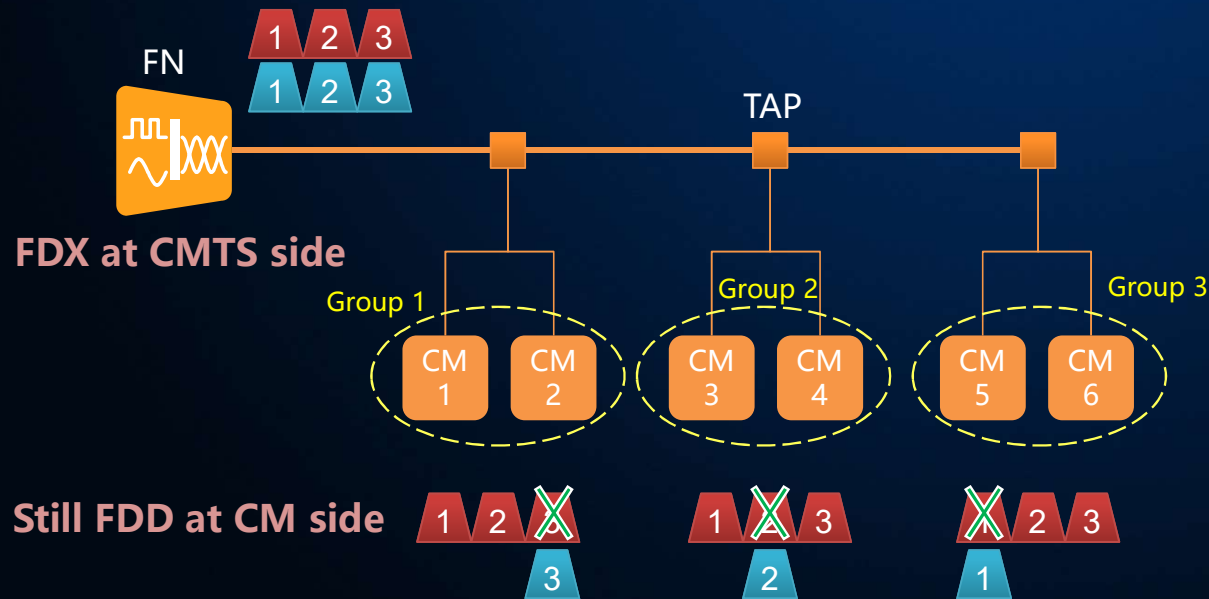
## Fiber Deeper

- N+x to N+0
- FTTLA to FTTT

**FDX** (Full Duplex) and **ESD** (Extended Spectrum DOCSIS) are the two key technologies for NG Cable.



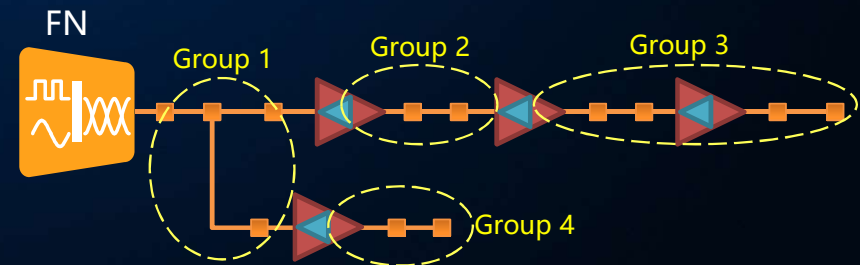
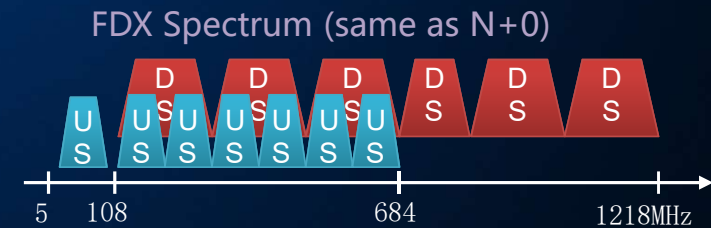
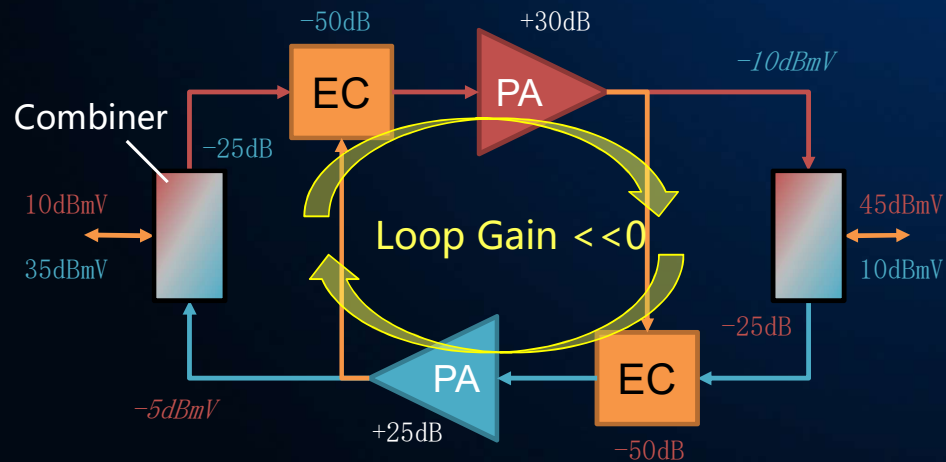
# Full Duplex for N+0 Scenario



- FDX Spec has released more than 1 year (Jan 2018).
- No amplifiers in the plant since conventional amplifiers work in FDD mode.
- Grouping CMs based on the isolation between CMs.
- Upstream capacity increase to 5Gbps, downstream is 10Gbps same as D3.1.

# Full Duplex Amplifier for N+x Scenario

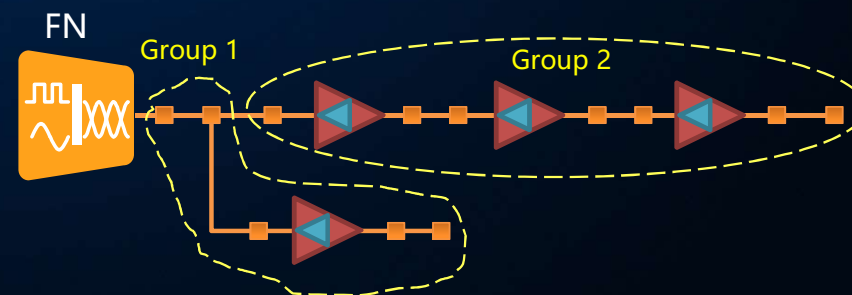
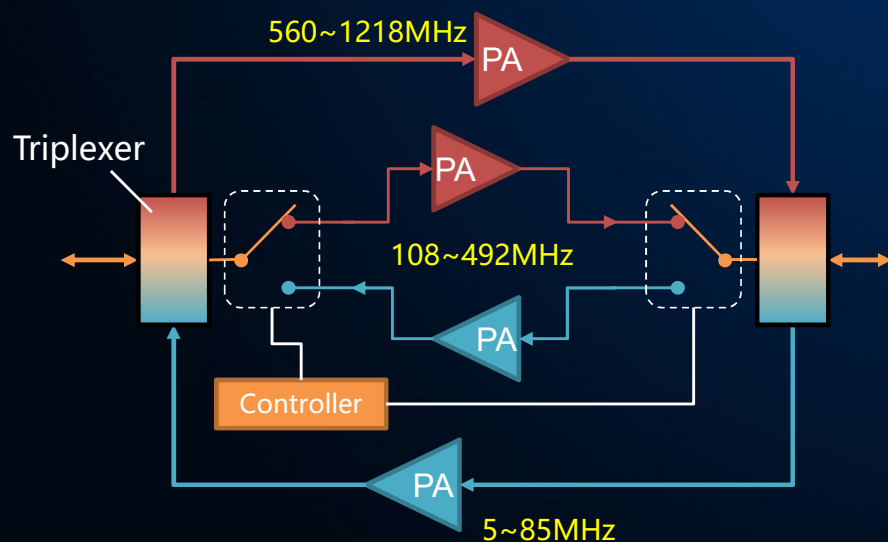
## Solution 1: FDX Amplifier work with Echoes Cancellation



- FDX Amplifier is possible in theory.
- More complicated, More cost, More power consumption.
- 5G/10G at N+x Network, all conventional amplifier need to change.

# Full Duplex Amplifier for N+x Scenario

**Solution 2:** FDX Amplifier work in TDD mode (DS and US work at different time)



- Not real FDX amplifier, downlink and uplink amplify different spectrum at one time.
- Embedded CM inside to synchronize with CMTS, switching DS/US at right time.
- Only two groups, have to divide them at first stage amplifier.
- Much cheaper than EC Amplifier.

# Key Challenges of Full Duplex



## □ Network Upgradation

- If N+0: fiber deeper, low power consumption for fiber node.
- If N+x: replace all amplifiers.
- Conventional TV channels must be move to high spectrum or in all-IP.

## □ More Expensive devices

- CMTS: add EC, Scheduling, grouping, RBA(Resource block allocation)
- CM: add EC for ACI (Adjacent Channel Interference) and ALI (Adjacent Leakage Interference)
- Amplifier: add EC or D3.1 CM, more PAs, switches.

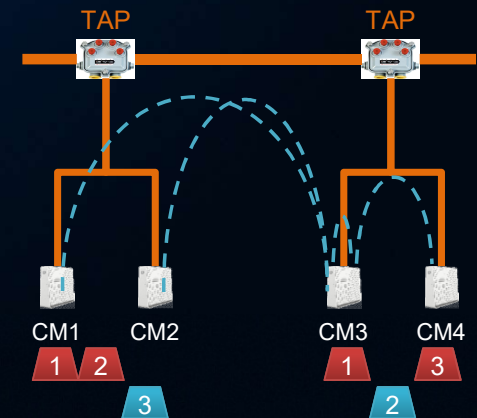
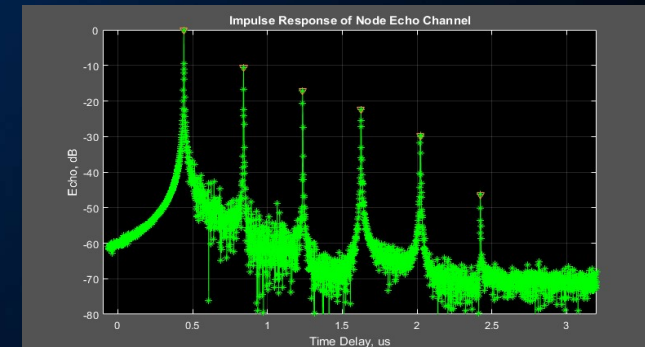
## □ Echo Cancellation

- Echo is higher than receive signal.
- Echo with multipath.
- Echo with high noise floor.

## □ FDX Grouping

- In some old and poor cable plant, FDX performance may be worse than conventional FDD, since the interference between groups cannot be cancelled.

Impulse response of Echo



Interference between CMs

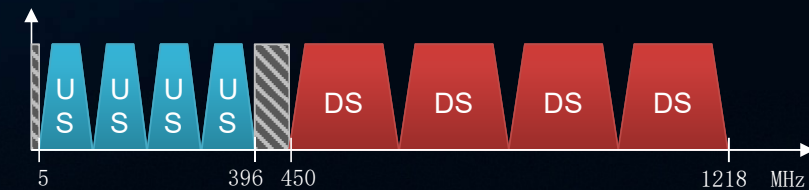


# Extend Spectrum with 'Ultra-High-Split'



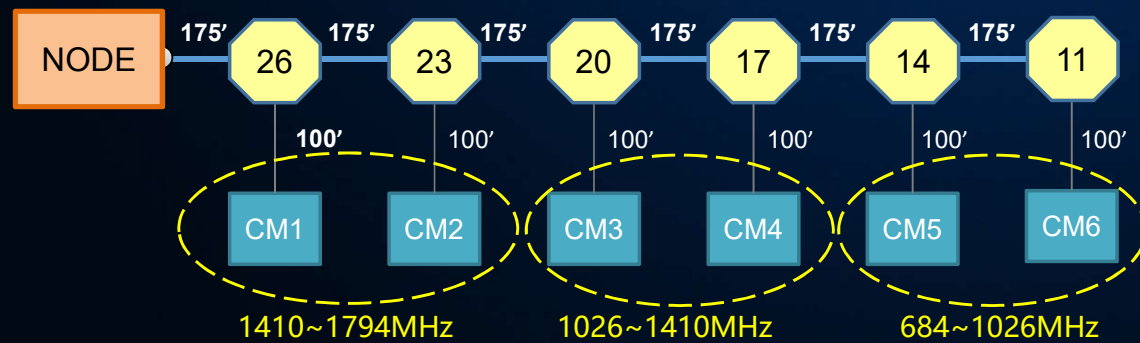
DOCSIS Split Mode	Upstream Spectrum	Downstream Spectrum	Guard Band
Low Split	5~42 MHz	53~1000 MHz	11 MHz ( $\approx 42 \times 0.27$ )
Middle Split	5~85 MHz	108~1000 MHz	23 MHz ( $\approx 85 \times 0.27$ )
High Split	5~204 MHz	258~1218 MHz	54 MHz ( $\approx 204 \times 0.27$ )
Ultra High Split	5~396 MHz (TBD)	450~1218 MHz	54 MHz ( $\approx 396 \times 0.14$ ) <i>If as before: 107 MHz (<math>\approx 396 \times 0.27</math>)</i>

- Conventional FDD is much simpler and better performance than FDX.
- The guard band waste more spectrum as upstream go higher.
- Diplexer performance should be improved to narrow the GB.
- Ultra-High-Split is a special case of FDX spectrum, it could be consider as a transitional scheme to FDX.

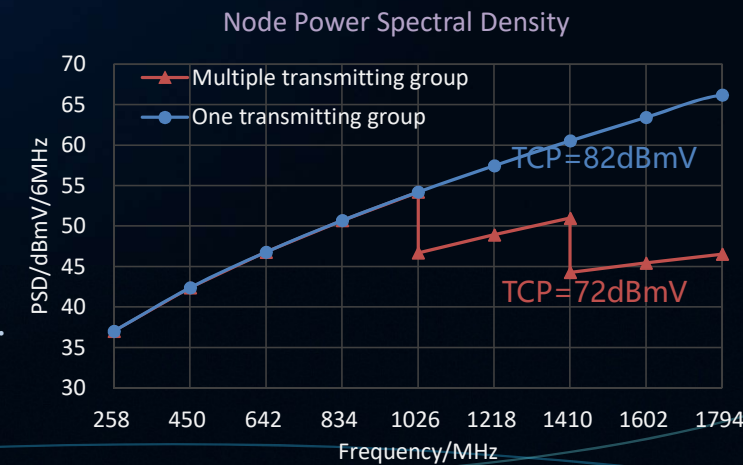
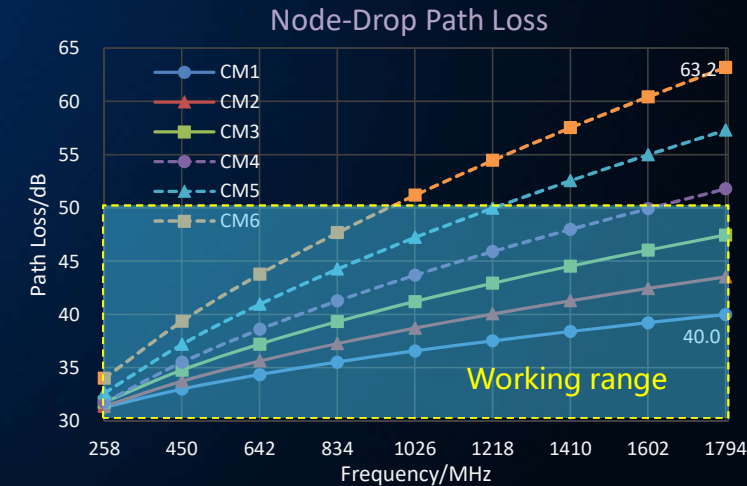


Ultra-High-Split Spectrum Example

# Extend Spectrum to 1.8GHz



- If extending to 1.8GHz, get additional 3\*192MHz spectrum.
- Attenuation at high frequency is much more than low frequency.
- Down-step power at high frequency to decrease Transmit Composite Power.
- Grouping CMs based on distance or path loss should be considered to improve total efficiency.



## Extend Spectrum to 3GHz or Higher



Pre-D3.0 and D3.0

Before



D3.1

Today



FDX & ESD to 1.8GHz

Near Term



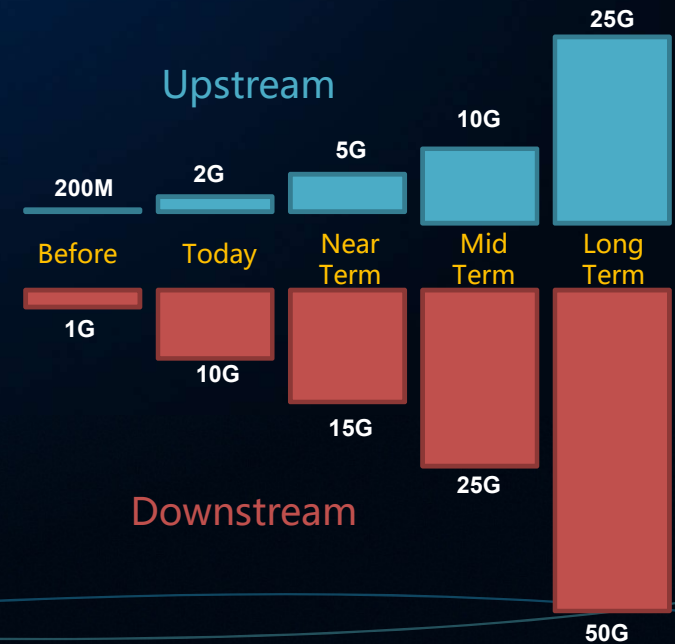
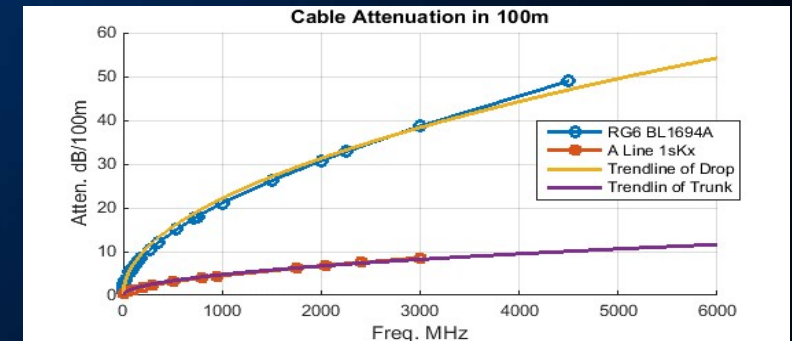
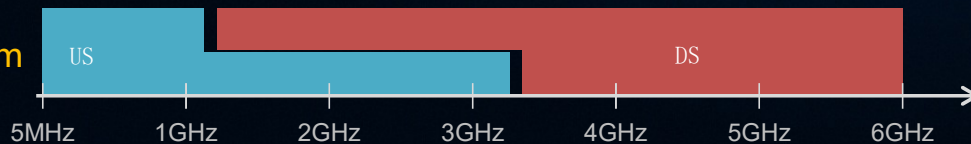
FDX & ESD to 3GHz

Mid Term



FDX & ESD to 6GHz

Long Term



# Key Challenges of Extending Spectrum



## □ Network Upgradation

- All network device(CMTS/CM/Amplifier) and components (Tap/Splitter) need to be upgraded to support higher frequency.
- Some poor coaxial cable may need to change.

## □ Higher Power Level Output

- More power need to compensate the more attenuation at higher frequency.
- More power consumption generated in devices.

## □ More Spectral Band

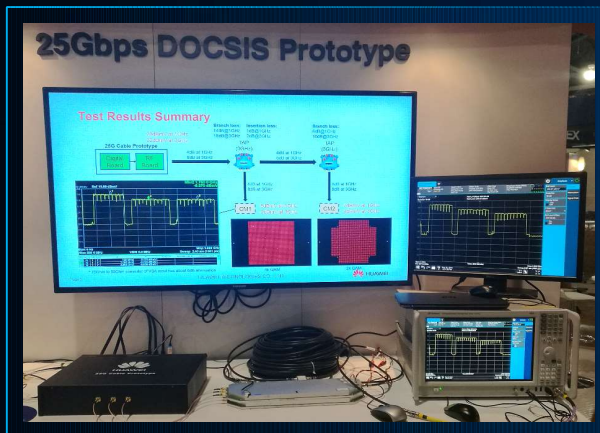
- Higher sample rate ADC/DAC.
- More channels.



# Huawei Leading in the NG Cable Research

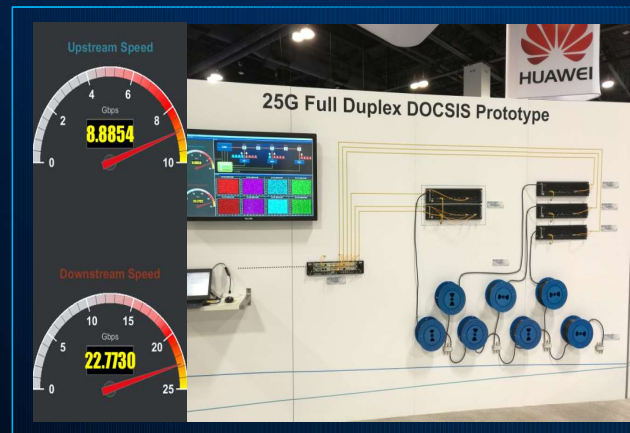


2016 SCTE



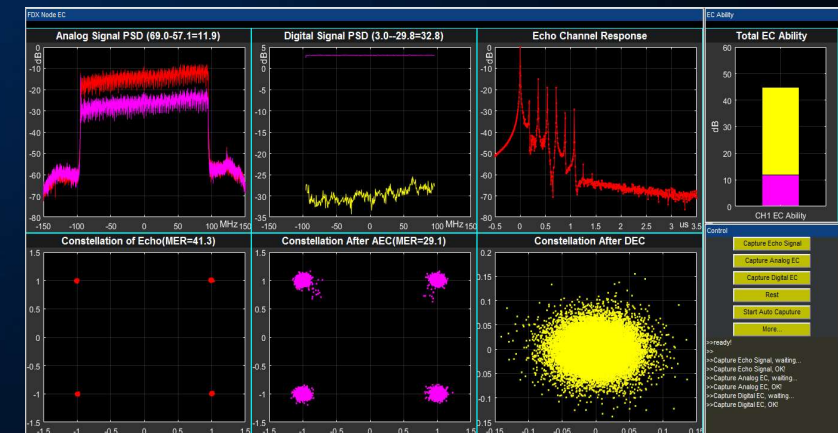
Industry-first **25G** Prototype

2017 SCTE



Industry-first **25G+FDX** Prototype

2018 CableLabs FDX-IOP



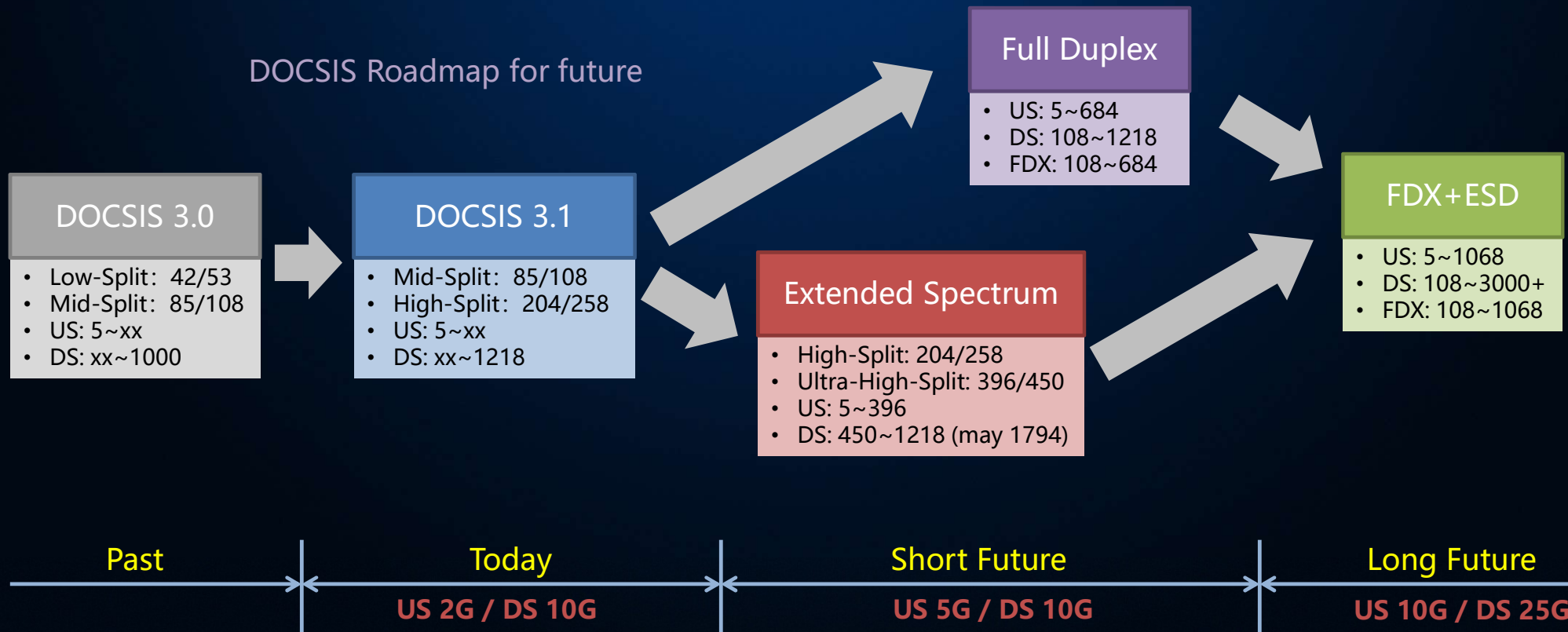
First attended the FDX IOP

- Huawei has done lots of research in NG Cable.
- We are continue to search the best way for extend Cable life-span.

# Cable has Long Life-span but with Tough Challenges



## DOCSIS Roadmap for future





# THANK YOU

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