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NETWORK PREPARATION: MAXIMIZING CAPACITY ROI

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ARRIS

Agenda

The Why of New Capacity (3)

New PHY Tools for New Capacity (6)

Obstacles to New Capacity &
Associated Strategies (7)

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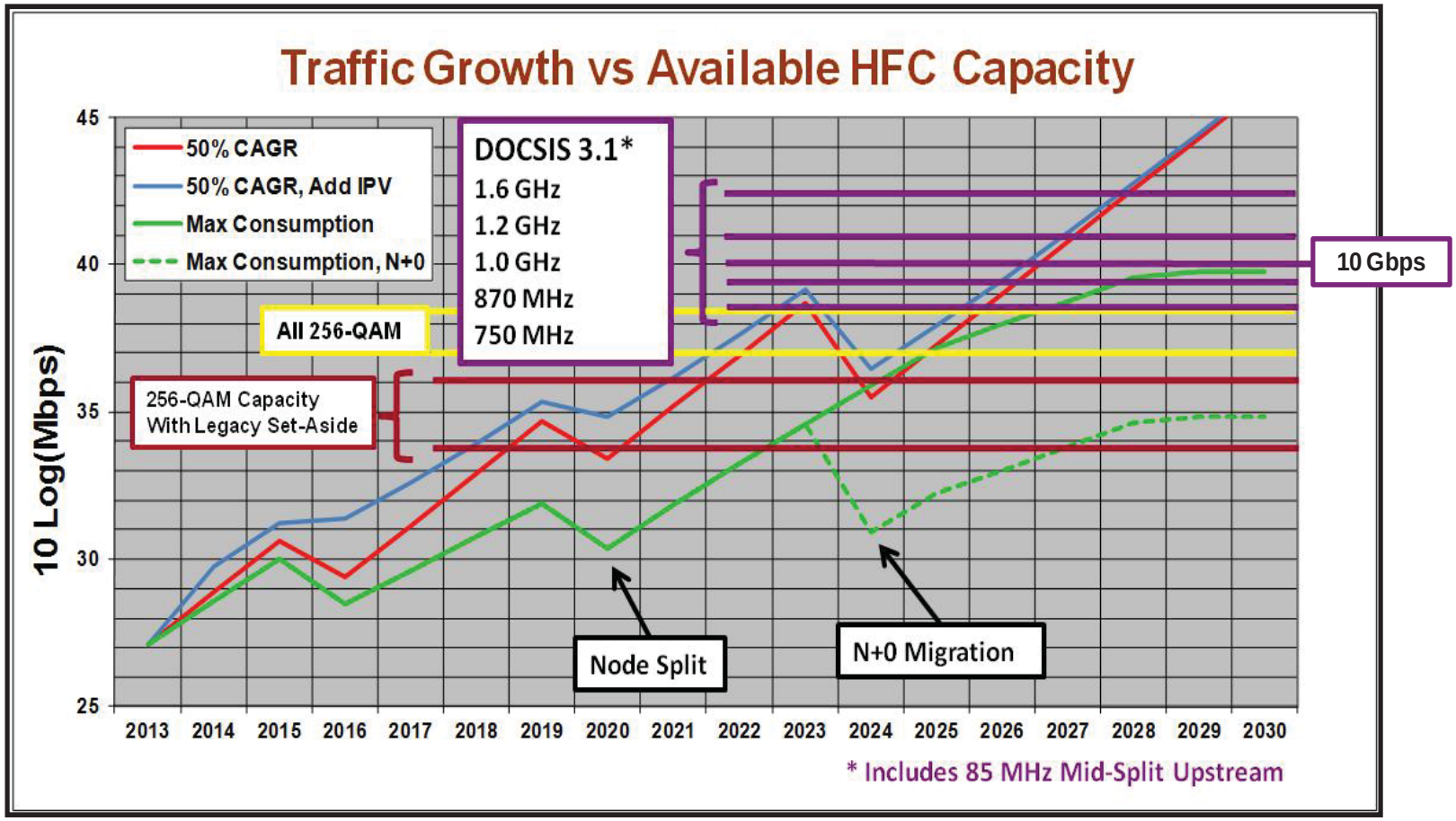
Conclusion

The Why of New Capacity

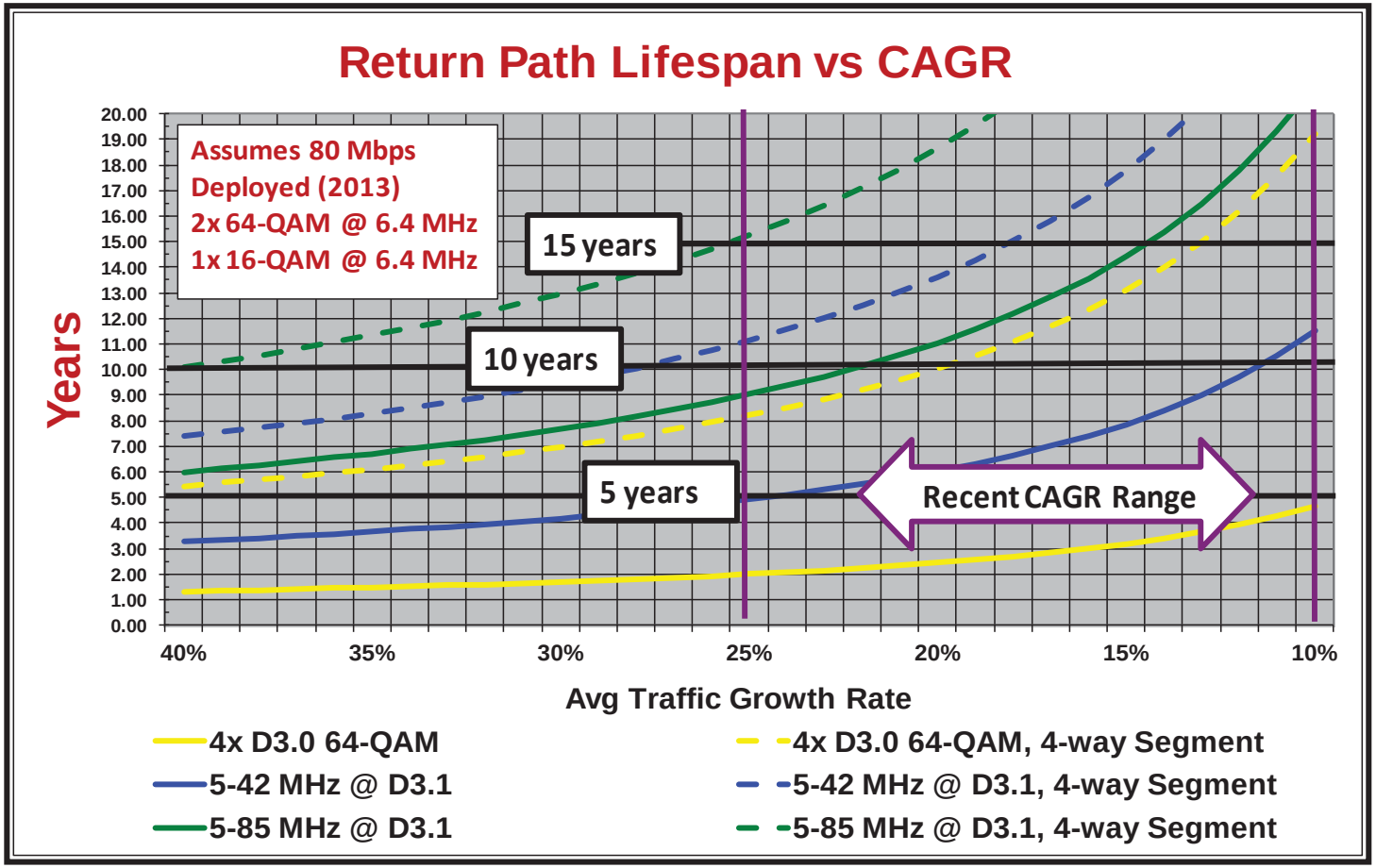
Why? Persistent Aggressive BW Growth



Compound annual growth rates of ~50% challenge lifespan

The push of the market – "billboard speeds" – also factors in

Cannot Ignore the Upstream



A lesser threat from a compound annual growth rate (CAGR) standpoint…recently
A problem statement with fewer alternatives to growth management

Simplifying New Capacity

Capacity = BW [Log_2 (1 + SNR)] *(BW = RF spectrum bandwidth)*

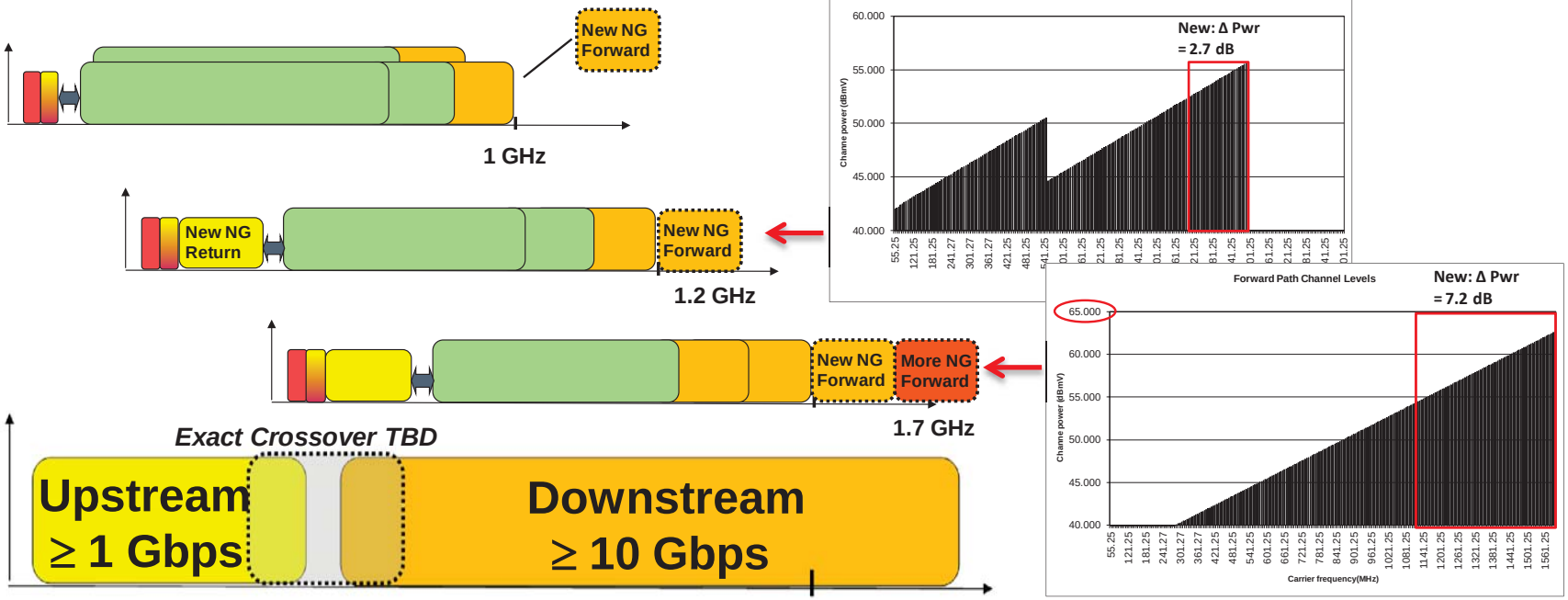
Handy back-of-napkin version:

Capacity = BW [SNR(dB)/3]

Architecture Evolution
- Fiber deep…deeper
- Digital Optics
- POE Home GW

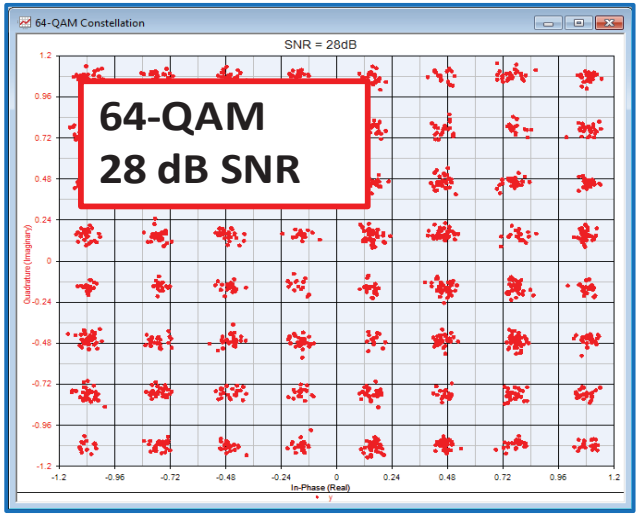
PHY Enhancement
- More BW-Efficient QAM
- Use the Best FEC

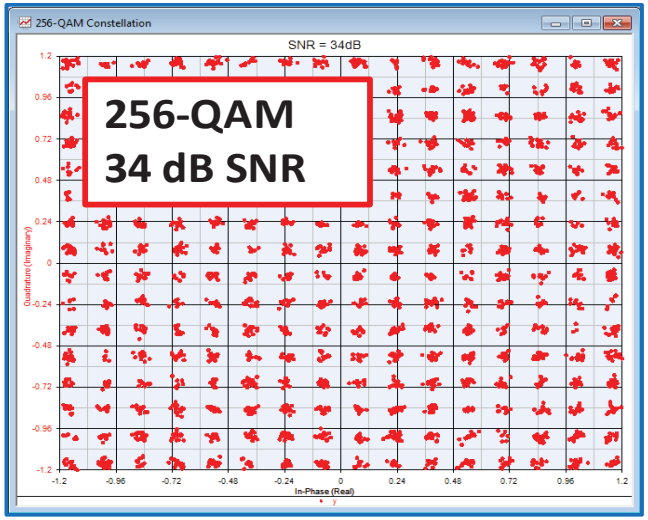
Spectrum: Reclaimed or New, D/S & U/S

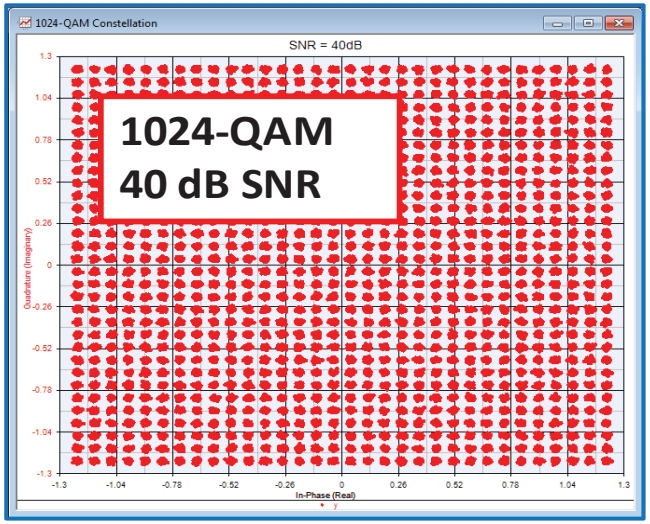


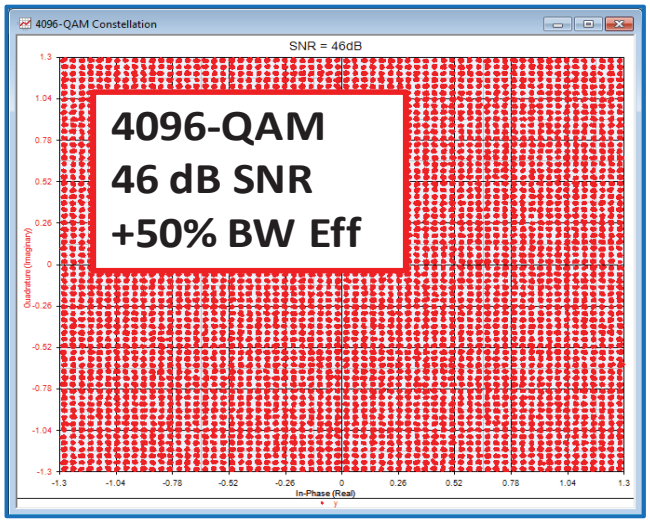
New PHY Tools for New Capacity

The M-QAMs (the Starting Point)









Shown at equivalent BER of 1e-8 (No FEC)

Single-Carrier OR one subcarrier of OFDM

158 "channels" (1 GHz of slots) @4096-QAM ~ 10 Gbps raw

"In-betweens": 512/2048-QAM

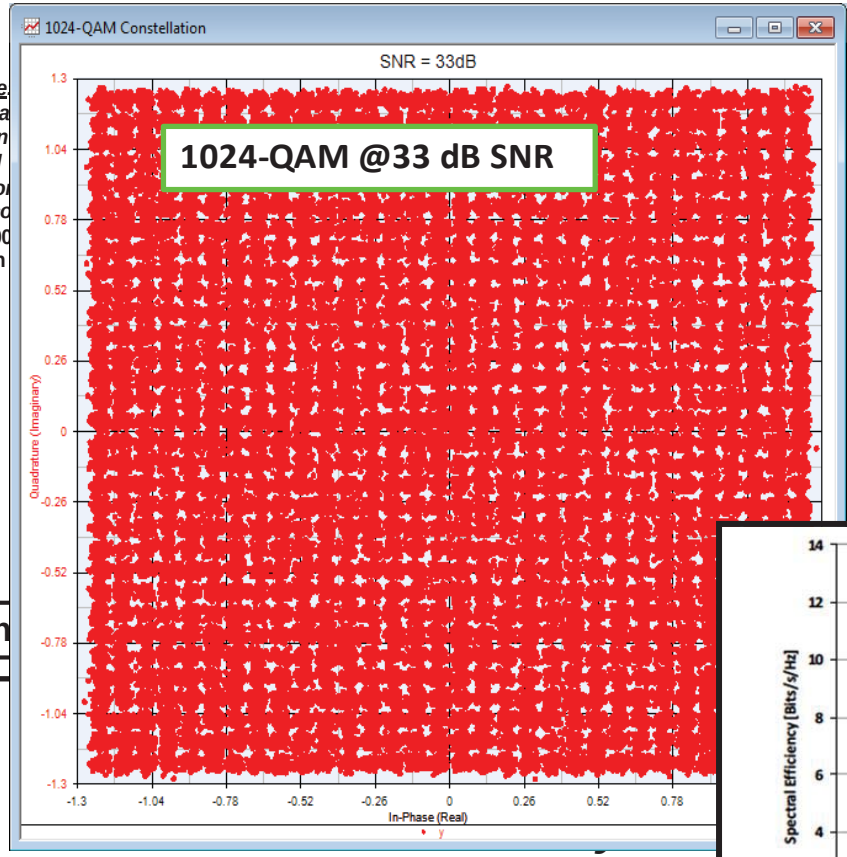
The Best FEC Family

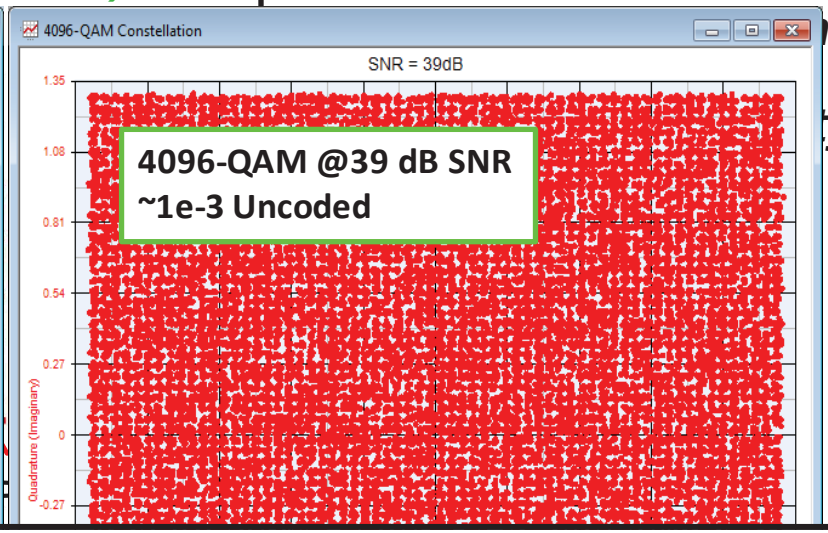
DVB-C2 ModCods vs SNR as simulated by ReDeSign

1024-QAM: 25 dB/27 dB/30 dB @ k/n = (75%, 83%, 90%)

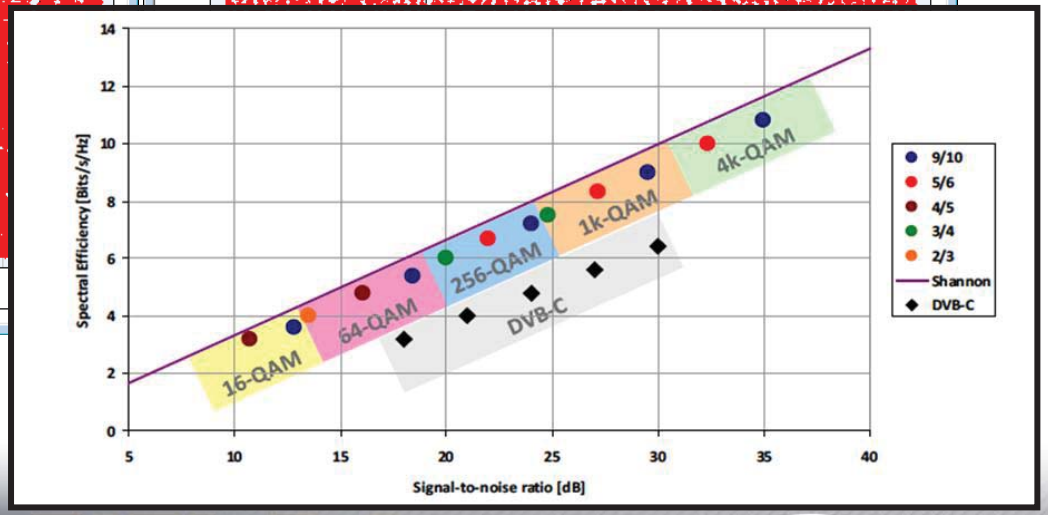
Reference
"Performa
evaluation
advanced
modulatio
channel co
30 Nov 200
ReDeSign
217014

High

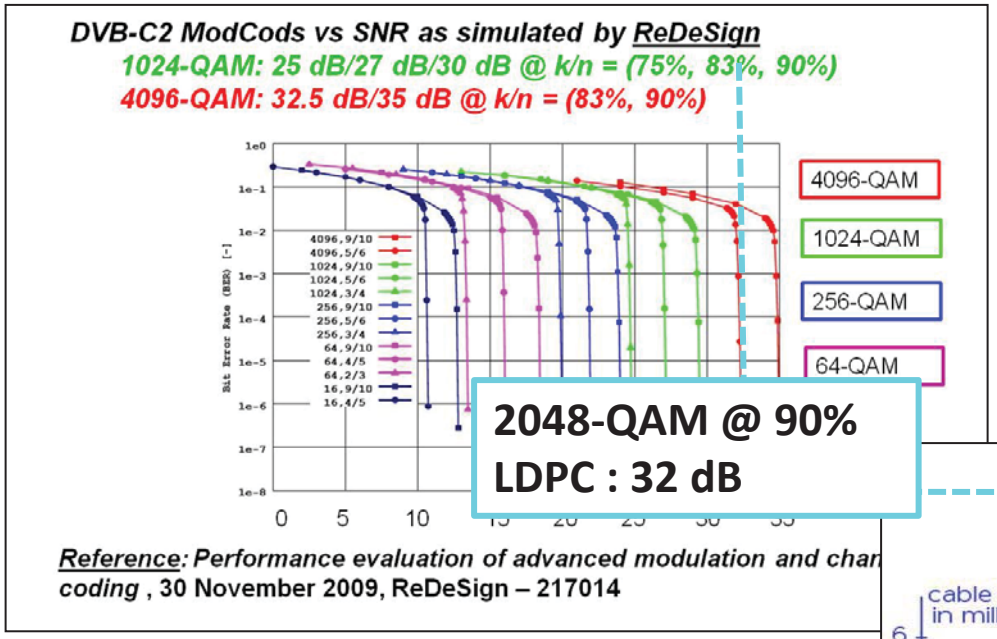




Theoretical capacity bounds

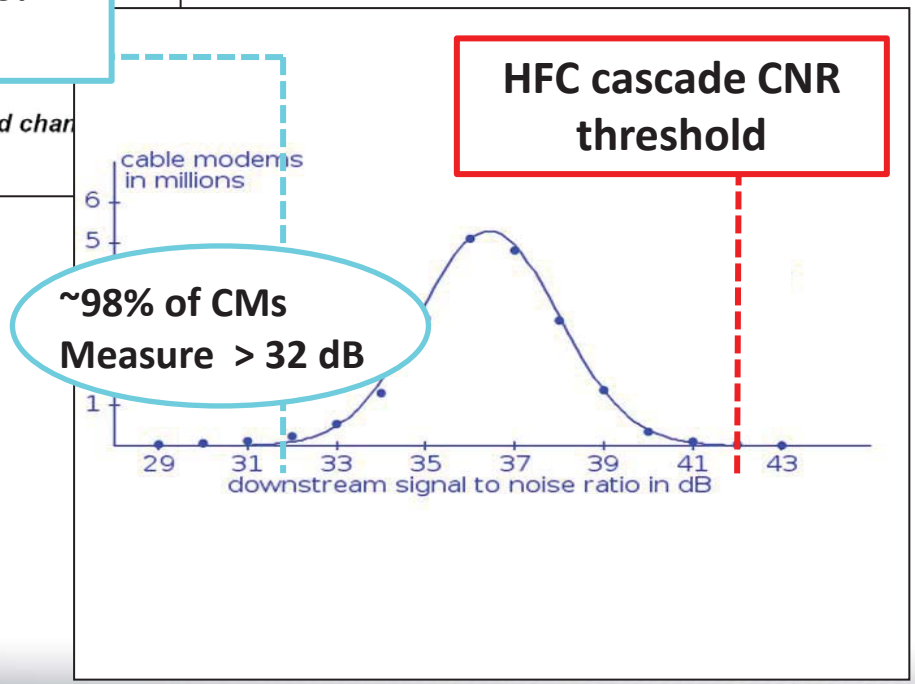


Field Reported SNR and Best FEC



Significant new capacity is available beyond 256-QAM

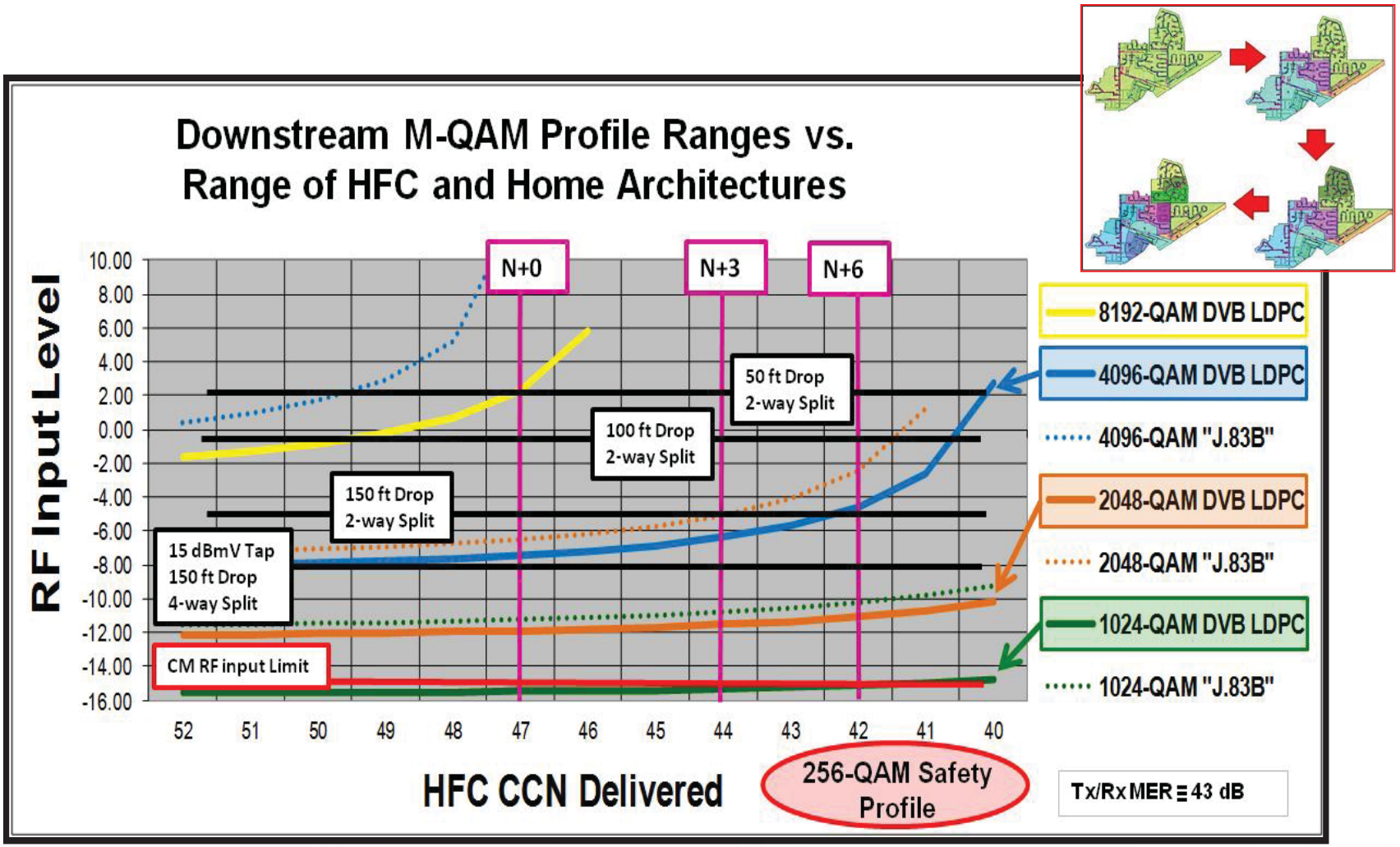
MER distribution of a large sample of CM's in the field today



Reference:
http://www.ieee802.org/3/bn/public/mar13/howald_3bn_01_0313.pdf

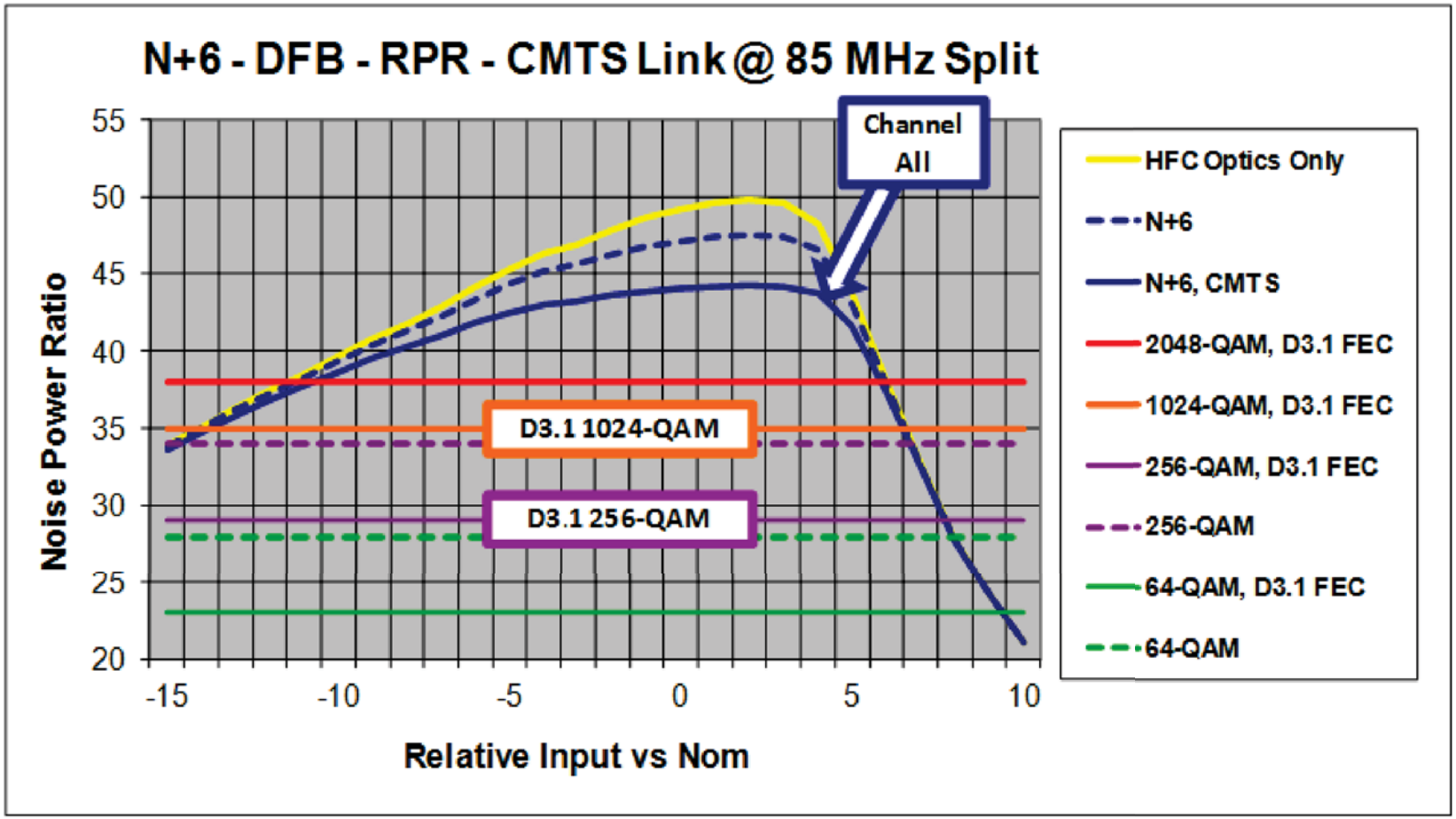
Stand Alone Fiber Deep HFC Performance

Tx / Rx Fidelity Removed (MER – Endpoints)

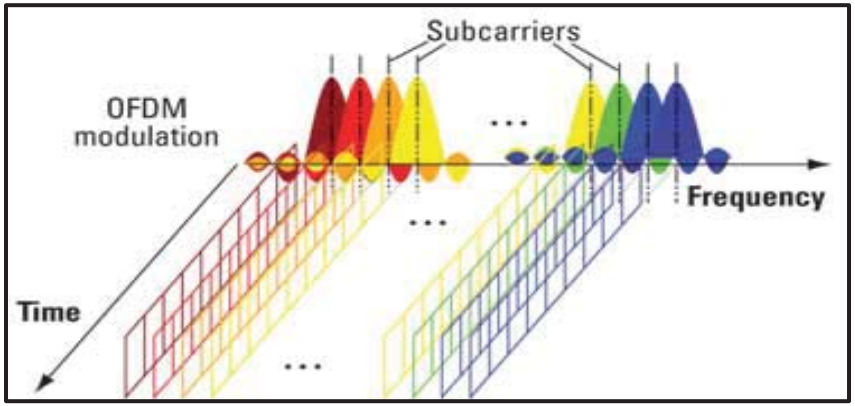


PHY Tools Applied to the Upstream

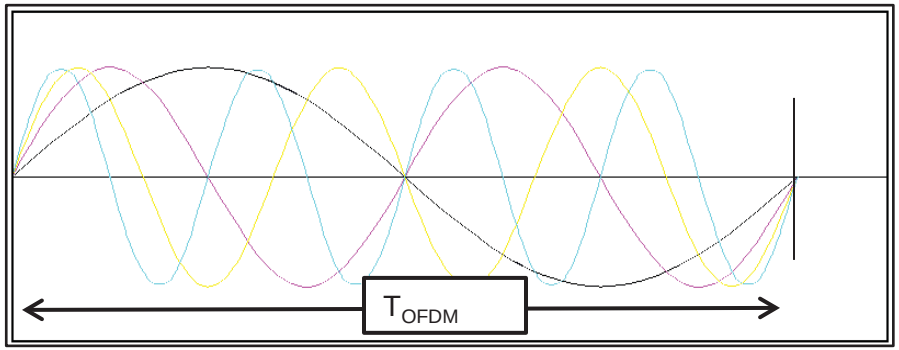
Alignment Practices Never More Critical



What About OFDM?



http://www.lightwaveonline.com/articles/ofdm-to-power-high-bit-rates-in-next-gen-optical-access-networks.html



http://www.dipol.ie/newsletter2/inf_dipo_2009_32.html

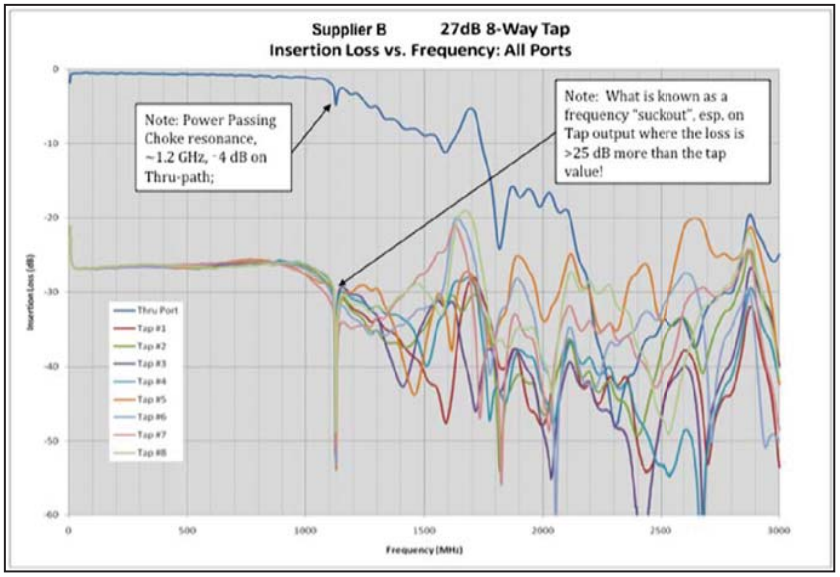
Capacity (high SNR case) ≈ (1/3) [Bandwidth] x [SNR(dB)]

Capacity, *long form*: $C \approx (1/3) \sum [\Delta f] [S(\Delta f) (\Delta BW) / N(\Delta f)]_{dB}$

- **OFDM subcarriers = ΔBW (narrow subcarriers)**
- **SNR not uniform over the entire bandwidth; optimal QAM per SNR**
  - **Wideband channel**
- **Minimize capacity lost to difficult channel (i.e. Plant) conditions**
  - **Poor freq response, including roll-off bands**
  - **Structural micro-reflections (multi-path)**
  - **External interference**

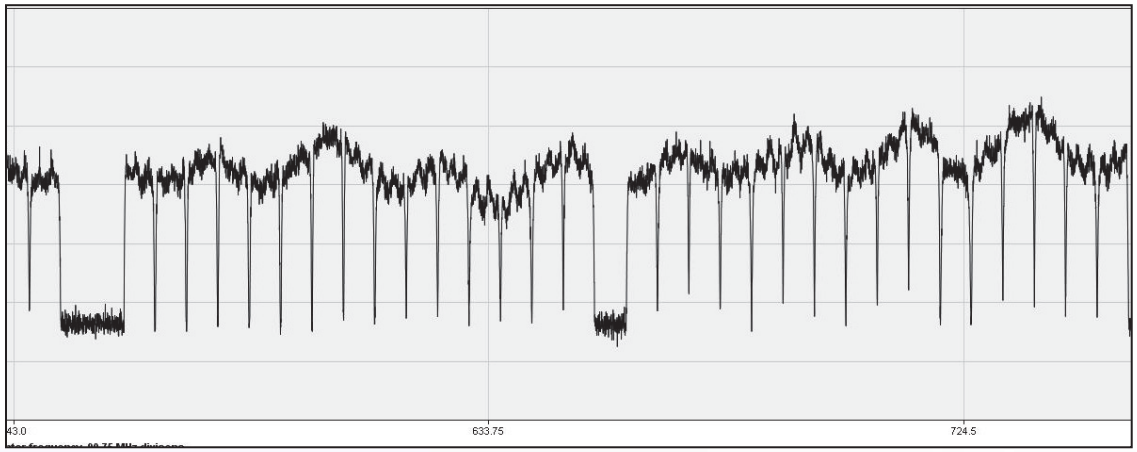
Obstacles to New Capacity & Associated Strategies

Poor Frequency Response



"Excess" bandwidth exists above 1 GHz in roll-off region for 1 GHz Taps

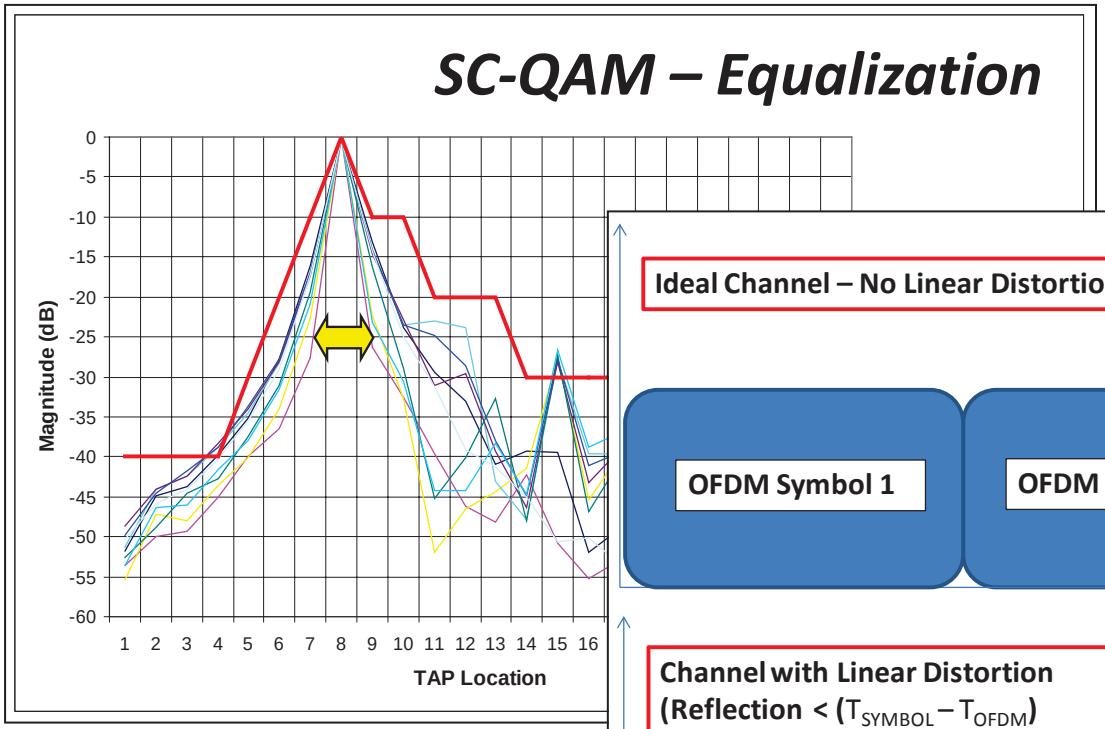
OFDM subcarrier bit loading maximizes capacity of excess bandwidth

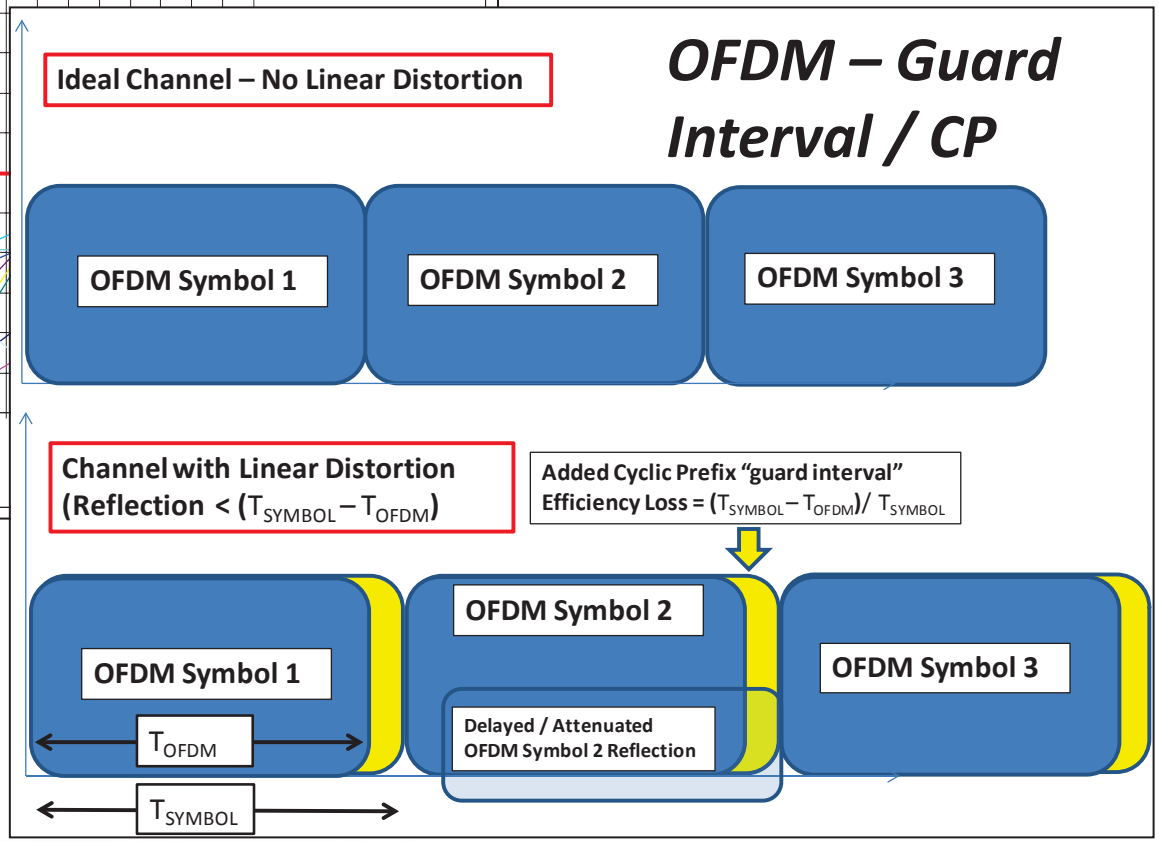


Full-Band Capture Tools in Modern D/S CM's

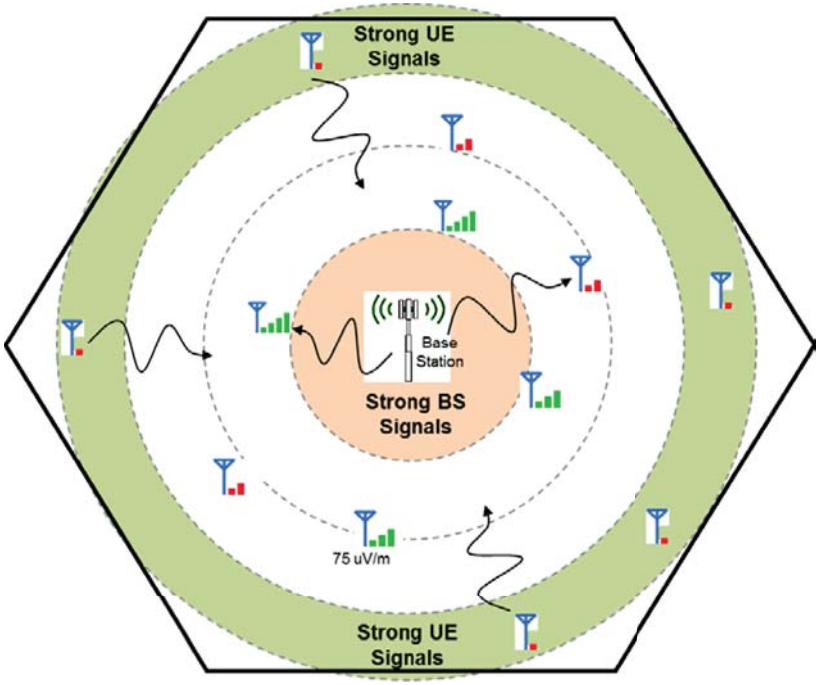
Evidence of multiple plant micro-reflections (OFDM cyclic prefix)

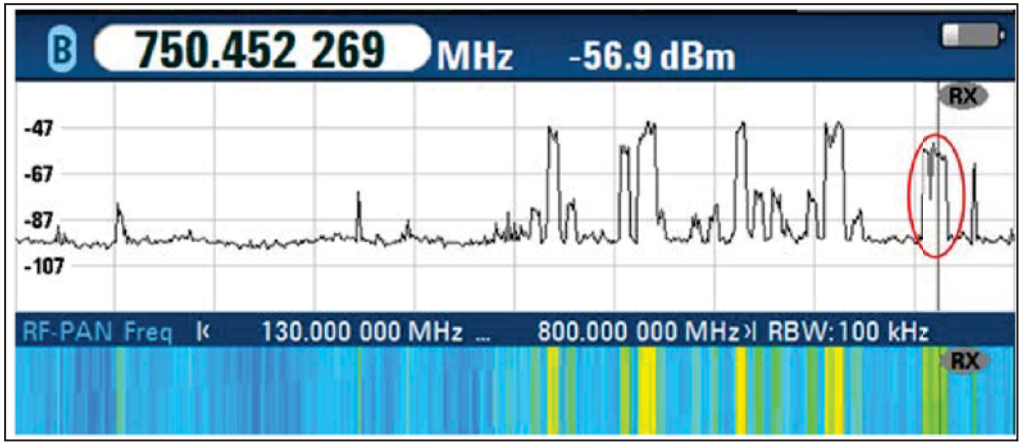
Structural Micro-Reflections

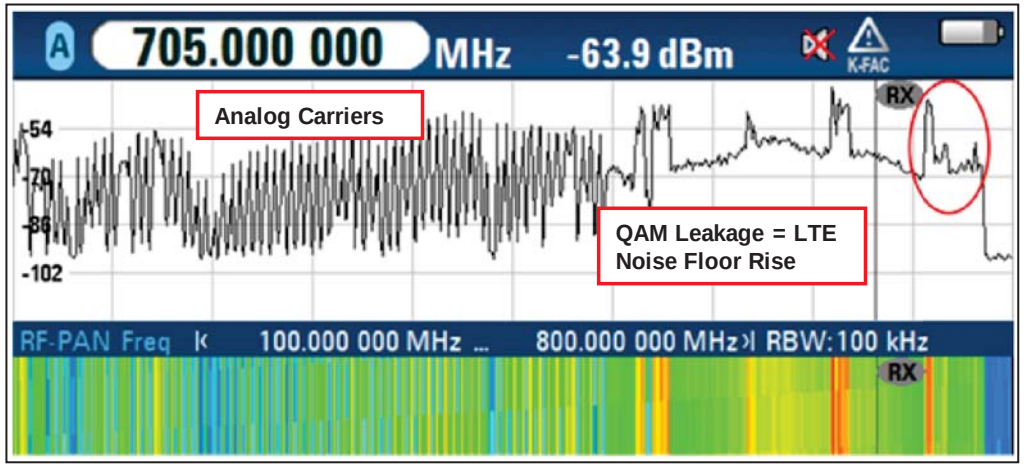




Fixed Frequency Interference



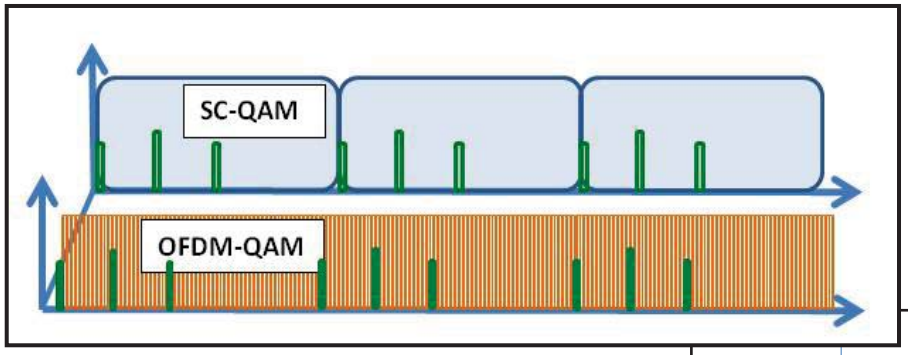




Multiple mechanisms for emerging LTE interference to contend with – plant & home

Where there is QAM leakage……

Managing Freq Domain Interference



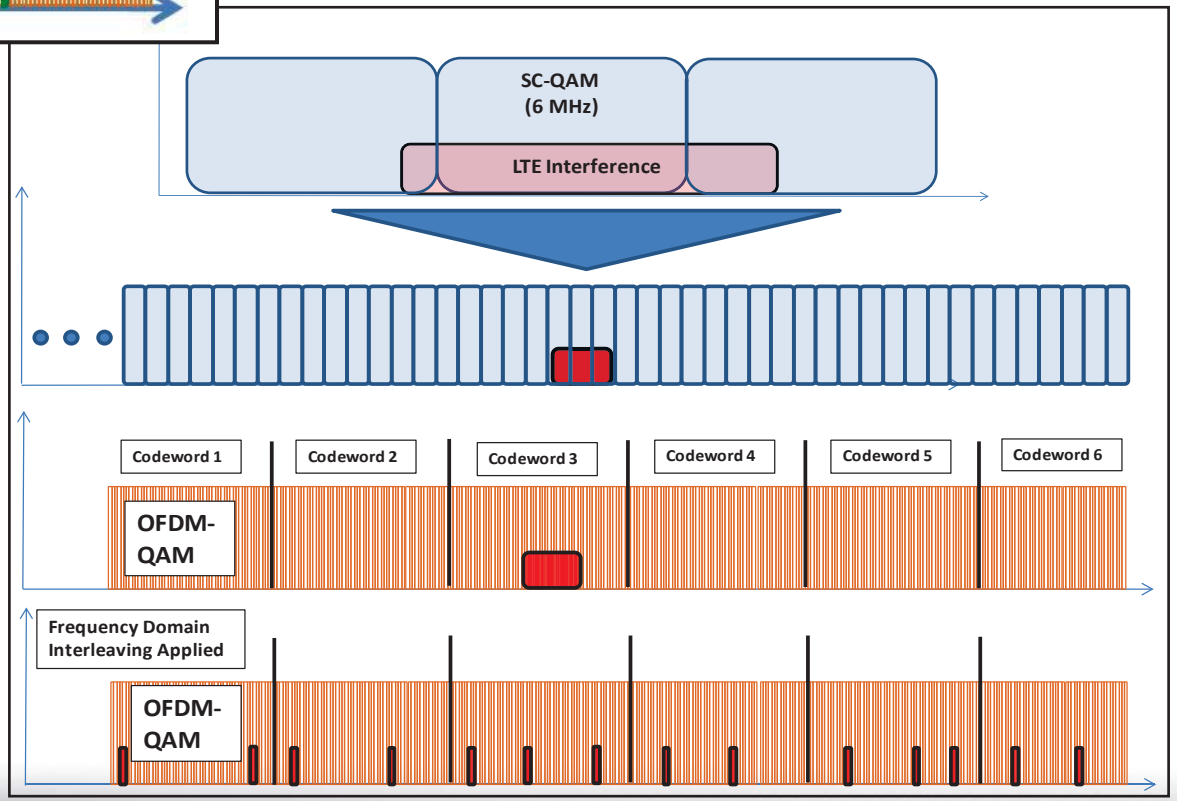
Narrowband interference: *CTB/CSO, ingress, shortwave (upstream)*

Mitigation*: bit loading or mod/cod scheme;* ***analog reclamation***

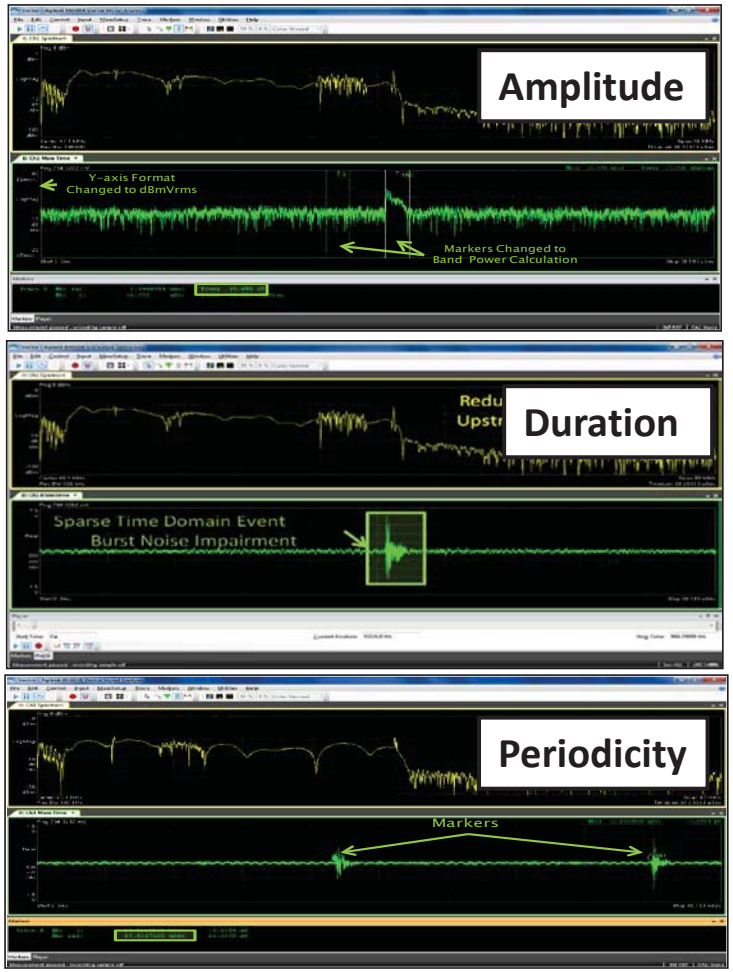
Contiguous interference: *LTE*

Mitigation*: Subcarrier interleaving + bit loading or mod/cod scheme; plant & home integrity*

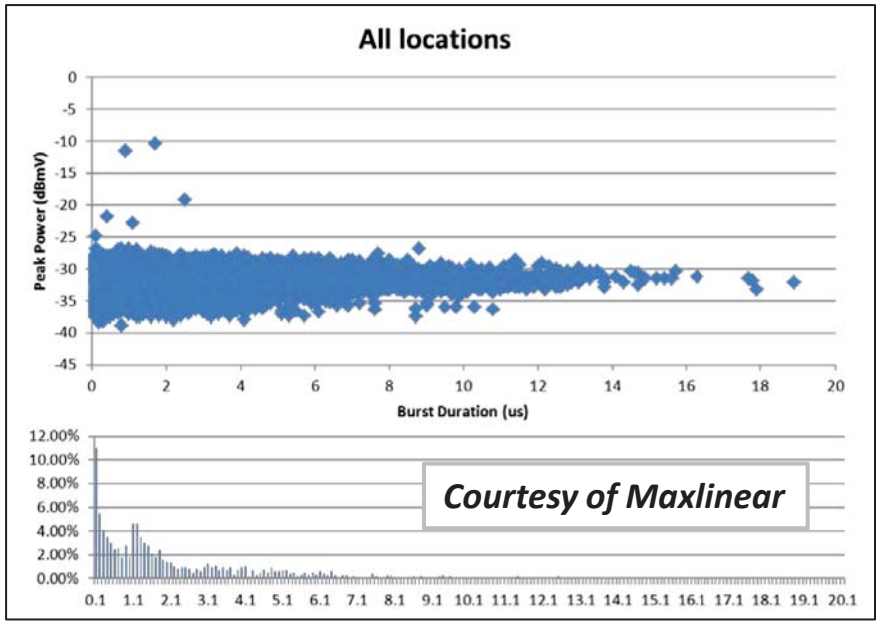
Readiness?*: 40 MHz of LTE? Nowhere to hide*



Transient Interference (Burst Noise)

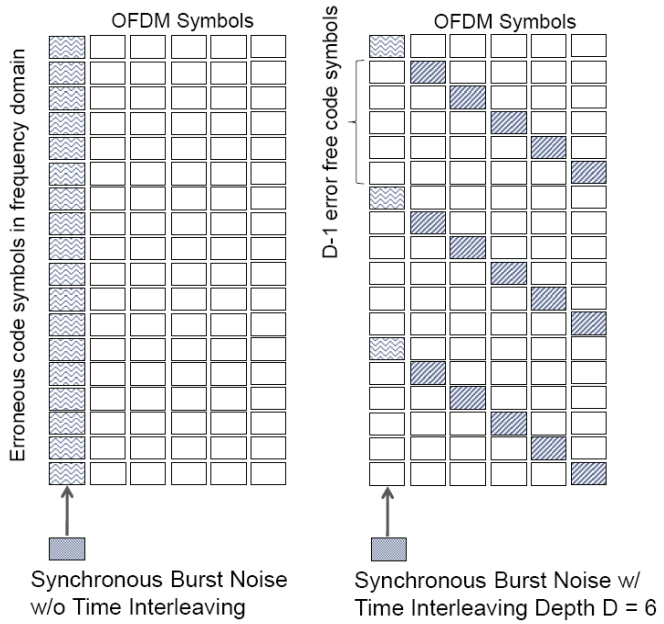


Statistical descriptions
guide system design parameters



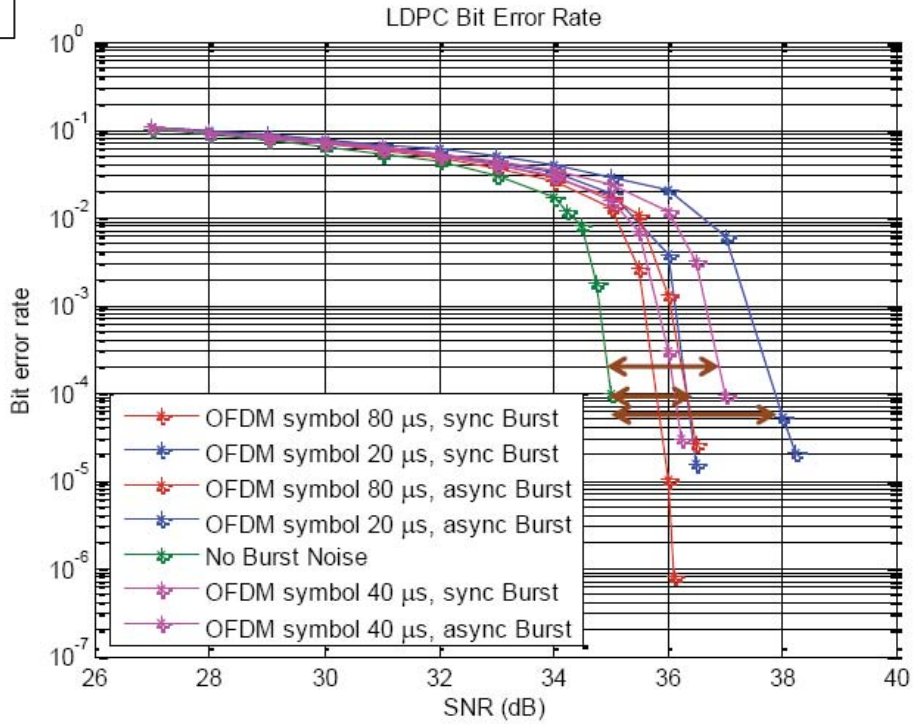
Managing Transient Interference

System optimization:
Symbol duration + FEC + interleaving



Simulation Results Courtesy of Qualcomm

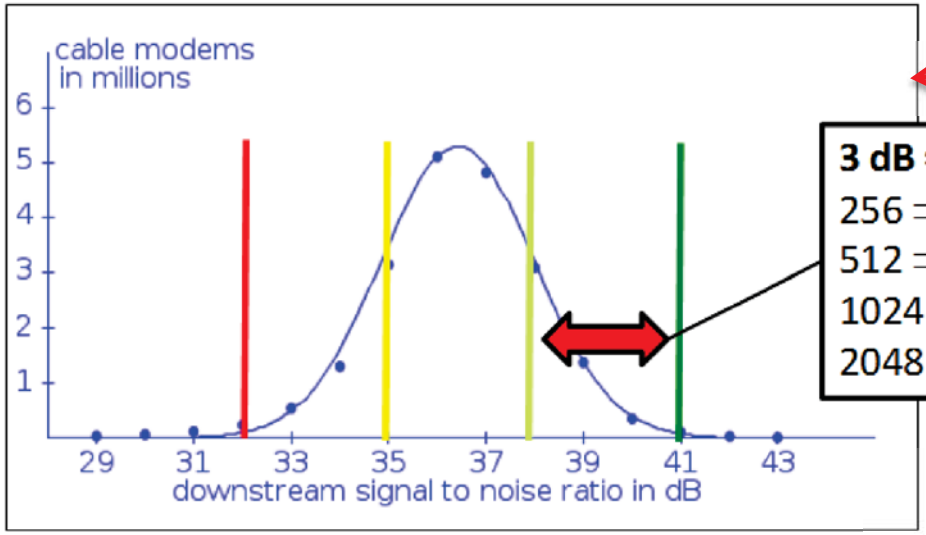
http://www.ieee802.org/3/bn/public/jan13/pietsch_01_0113.pdf



- Modest burst levels – half QAM order lost
- Intermittent – difficult to ID cause; MER ok
- Best practices at install to minimize probability of events

Unique D3.1 Optimization

Major Change to D/S Access & Configuration

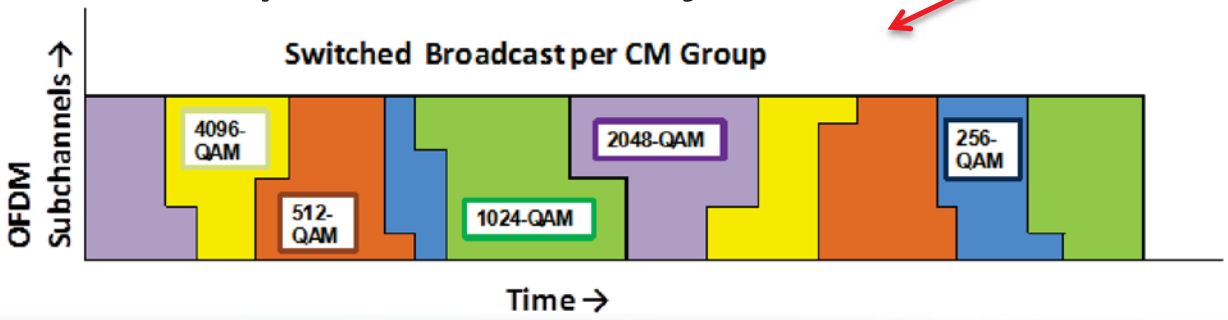


3 dB = 1 bps/Hz
256 ⇒ 512-QAM
512 ⇒ 1024-QAM
1024 ⇒ 2048-QAM
2048 ⇒ 4096-QAM

There is an SNR range observed in the field today

Some CMs can do more than others…so let them do so

Multiple Modulation Profiles, or MMP



Net capacity higher than "least common denominator"

Recommendations Summary

Practices

- Home gateway architecture – *New reference architecture*
- Grounding/shielding integrity – *Increased importance*
- Home network technologies – *Emerging larger threat*
- CPE overload potential – *Getting worse (MoCA™ + split)*
- MDU care & feeding – *Increased importance*
- Drop/home robustness – *Increased importance*
- Craft/expertise for expanded D/S – *New, a maybe*

Operations

- New diagnostic and proactive metrics – *New information*
- Significance of proper level alignment – *Old, no excuses*
- Leakage detection and repair – *Ingress oppt'y getting worse, increased importance*
- Impairment localization via diagnostics – *Can do better, increased importance*

Recommendations Summary (cont'd)

Potential capex investment

- Migration with a (frequency) plan
- DFB or baseband digital return
- New CCN and MER targets
- CPE shielding effectiveness
- Analog reclamation
- Equipment for > 1 GHz?
- Digital optics with remote RF architectures

Workforce Training

- What is OFDM/OFDMA
- Digital optics for plant guys
- Upstream loading (again)
- Impairment location through diagnostics
- Multiple modulation profiles & configuration
- Install processes for POE home and MDUs
- Advanced diagnostics: full band capture, FEC stats, constellation signatures, MER-per-symbol, burst signatures

Conclusion

The HFC network is under pressure from persistently aggressive CAGR and market peak rate wars

The HFC network is presently used well below capacity

DOCSIS 3.1 aims to exploit HFC to its maximum potential

Technology, architecture, and spectrum can combine to achieve the target objectives and increase robustness

Each aspect has its own “readiness” implications

New technology and system design can only create new capacity potential

Operations, practices, investment, and training must be in place to fully exploit the potential of DOCSIS 3.1

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