10G or Bust: HFC & the Future Access Network

LiveLearning Webinars™ For Professionals

Thursday, July 15, 2021

11:00 am – 12:00 pm ET

TODAY'S WEBINAR IS SPONSORED BY:

cisco
harmonic
teleste intercept

SCTE a subsidiary of CableLabs® | LIVELEARNING WEBINARS™ FOR PROFESSIONALS

IN PARTNERSHIP WITH Light Reading

© Society of Cable Telecommunications Engineers, Inc. a subsidiary of CableLabs 2021 | scte.org

Information Classification: General

Today's Speakers

Alan Breznick
Cable/Video Practice Leader
Light Reading

Dean Stoneback
Senior Director of Engineering & Standards
SCTE

Steve Condra
R&D and Product Management
Teleste Intercept

John J. Downey
Senior CMTS Technical Leader
Cisco Systems

Asaf Matatyaou
VP. Solutions & Product Management
Harmonic

Information Classification: General
© Society of Cable Telecommunications Engineers, Inc. a subsidiary of CableLabs 2021 | scte.org

Agenda

- **Light Reading -** 10G overview
- **Teleste Intercept -** Possibilities & limitations of ESD return path
- **Cisco -** Path to higher US throughput
- **Harmonic -** Cable broadband investment strategy
- **SCTE -** Training, standards & certifications
- **Audience Q&A**

Information Classification: General
© Society of Cable Telecommunications Engineers, Inc. a subsidiary of CableLabs 2021 | scte.org

Cable's Great 10G Quest

- Branded at CES in 2019 with 5G wireless in mind
- Access network agnostic: HFC, FTTP, wireless, etc.
- Targeting symmetrical speeds of at least 10 Gbit/s
- Enhanced security
- Lower latency
- Greater reliability

Information Classification: General

Cable's Early 10G Efforts

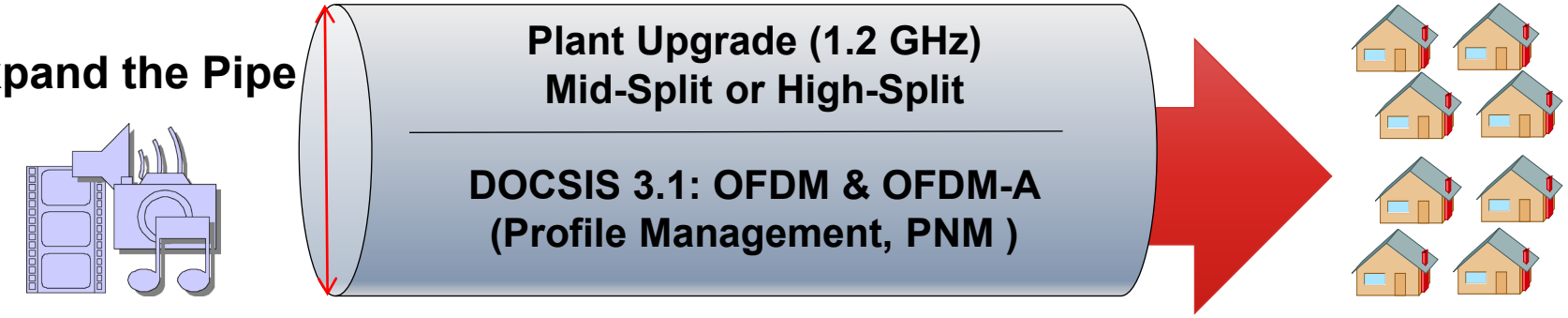
- Mediacom conducts 10G Smart Home demo in Ames, Iowa
- Comcast tests symmetrical 1.25 Gbit/s on HFC in Jacksonville, Fla.
- Virgin Media trials symmetrical 2.2 Gbit/s on HFC in Southampton & Manchester
- Comcast tests symmetrical 4+ Gbit/s over HFC (FDX) in Denver lab trial

Information Classification: General

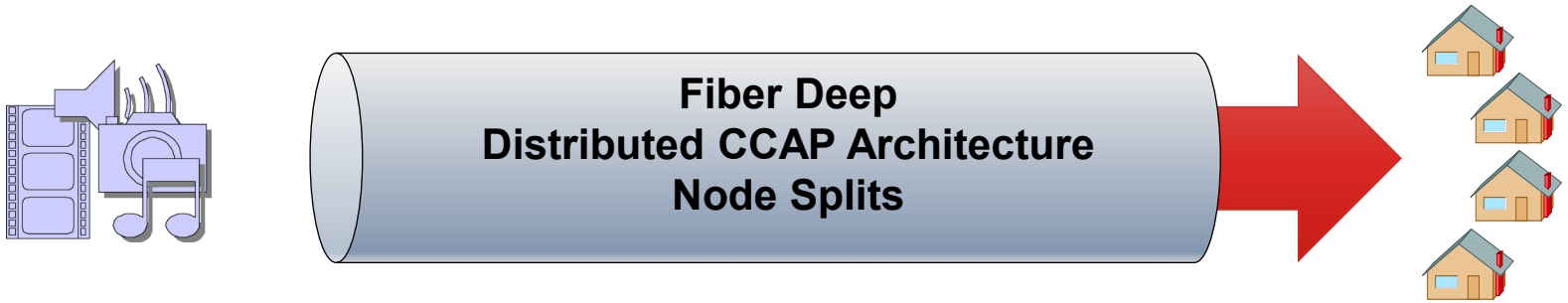
Scaling HFC Networks in 2020

CableLabs®

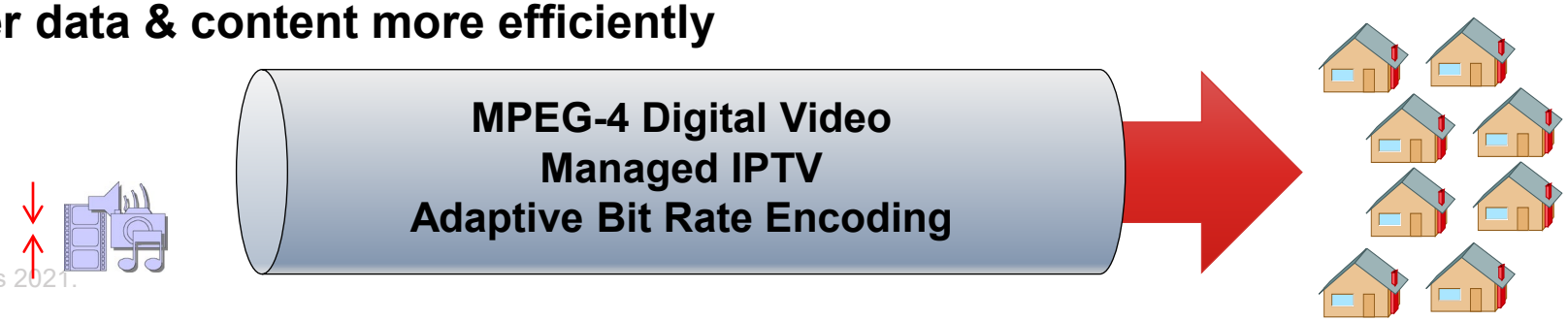
1) Expand the Pipe



2) Reduce # of homes sharing the Pipe



3) Deliver data & content more efficiently



© CableLabs 2021.

Information Classification: General

Steve Condra

R&D and Product Management

Teleste Intercept

SCTE · ISBE LIVELEARNING WEBINARS™ FOR PROFESSIONALS — IN PARTNERSHIP WITH — Light Reading

© Society of Cable Telecommunications Engineers, Inc. a subsidiary of CableLabs 2021 | scte.org

Information Classification: General

Possibilities and limitations of the Extended Spectrum DOCSIS return path

Steve Condra
Senior Director, Engineering and Product Management
Teleste Intercept

Teleste Proprietary. All rights reserved.

Preface

"DOCSIS 4.0 technology supports up to 10 Gbps speeds downstream capacity and up to 6 Gbps upstream capacity, easily allowing for multi-gigabit symmetric services over HFC networks."

https://www.cablelabs.com/technologies/docsis-4-0-technology

From HFC standpoint the higher upstream capacity requires

- Higher frequencies, higher gain, higher RF power
- Advanced constellations (1K, 2K OFDM) requiring better RF performance
- More advanced amplifiers (when N≠0)

- What "more advanced amplifiers" means, besides better RF performance …
- Why does the changing outdoor temperature become an additional challenge?

Improved RF stability = Higher MER; Higher MER = Higher Modulation; Higher Modulation = More Bits
More Bits = More $$

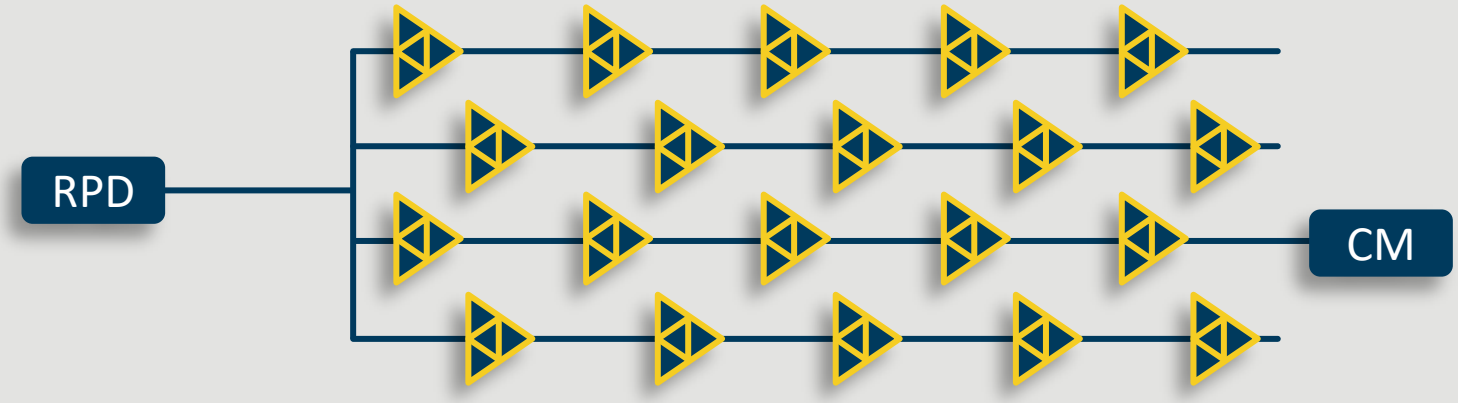
Teleste Proprietary. All rights reserved.

Information Classification: General

1K OFDMA upstream, amplifier clusters

- Noise cumulation (funneling), assumption: around 20 (4x5) amps below an RPD

$$MER_{RPD_US} = -10\log_{10}\left(10^{\frac{MER_{CM_US}}{-10}} + 4 \times 5 \times 10^{\frac{CNR_{amp}}{-10}}\right) \rightarrow MER_{RPD_US} \approx 40\ dB$$

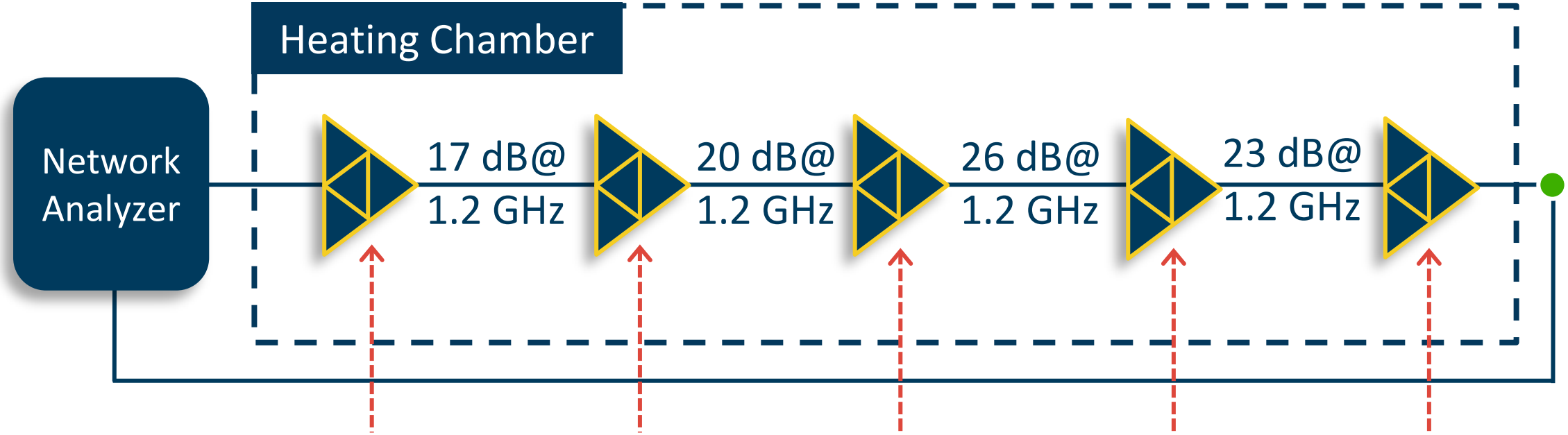


- However, due to the changing outdoor temperature…..

Teleste Proprietary. All rights reserved.

Information Classification: General

Test (from -4°F to 140°F)



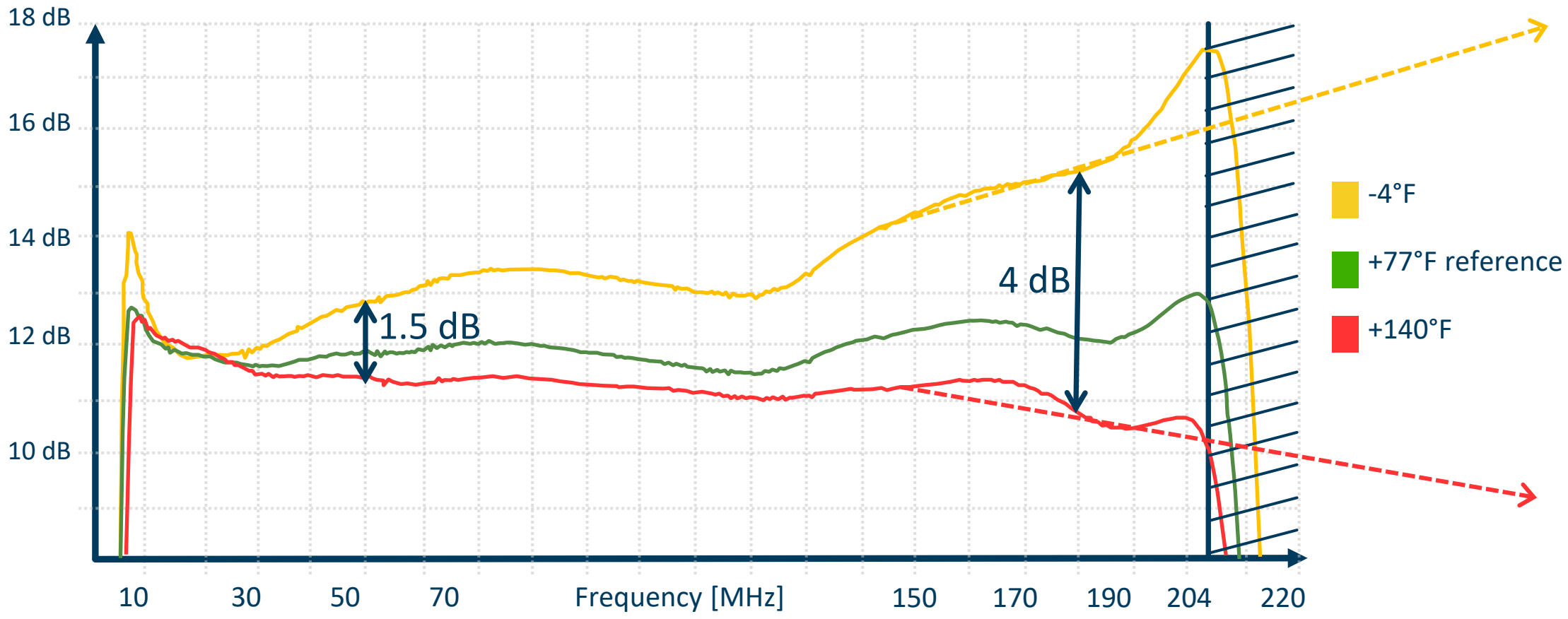
Note: Internal (but not external) temperature compensation always on

Coax: 100 ft = 2.83 dB @ 1.2 GHz, 100 ft = 1.07 dB @ 204 MHz

Teleste Proprietary. All rights reserved.

Information Classification: General

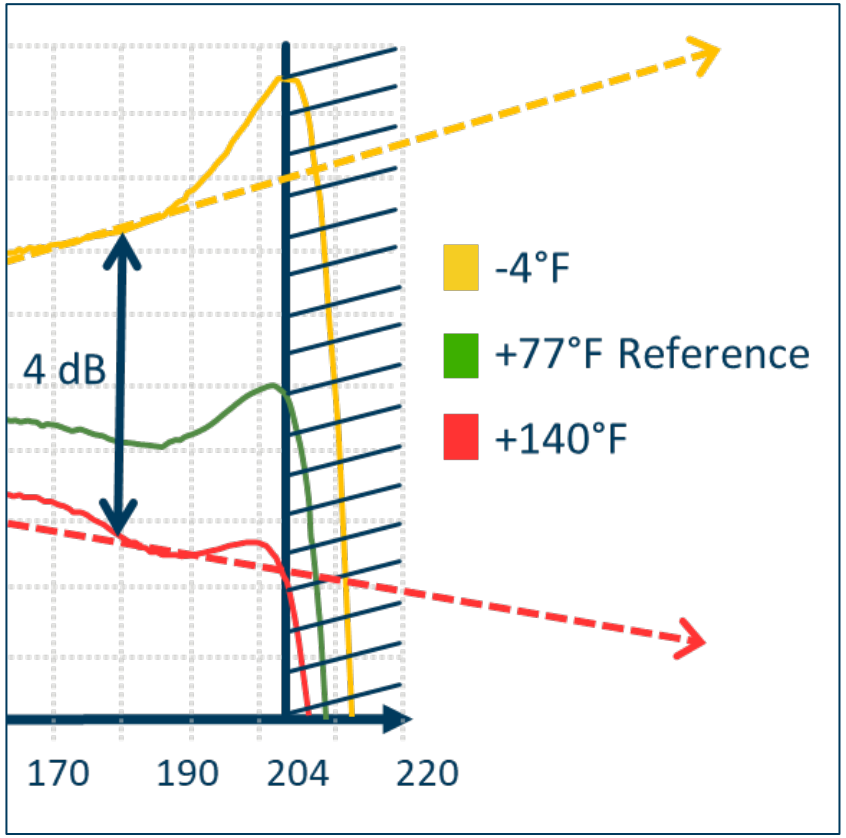
Upstream frequency responses



Teleste Proprietary. All rights reserved.

Information Classification: General

Consequences



Attenuation decreases, modems have lower output level, at some point input levels of amplifiers are too low.

→ Noise rises → Lower MER

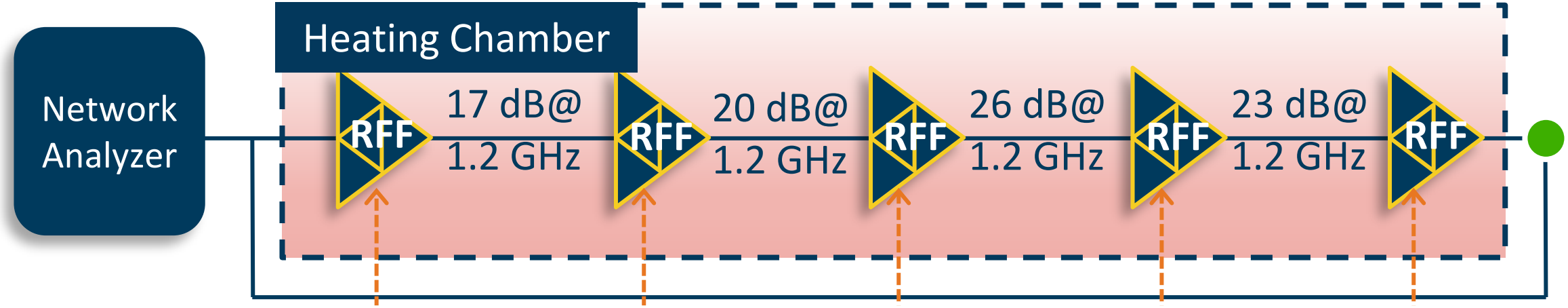
Attenuation increases, modems have higher (if possible) output level, at some point amplifiers are overloaded.

→ Distortion → Lower MER

Teleste Proprietary. All rights reserved.

Information Classification: General

Proposal



Note: Internal and external temperature compensation on

By following downstream changes, we can make real-time upstream adjustments

Return path gain

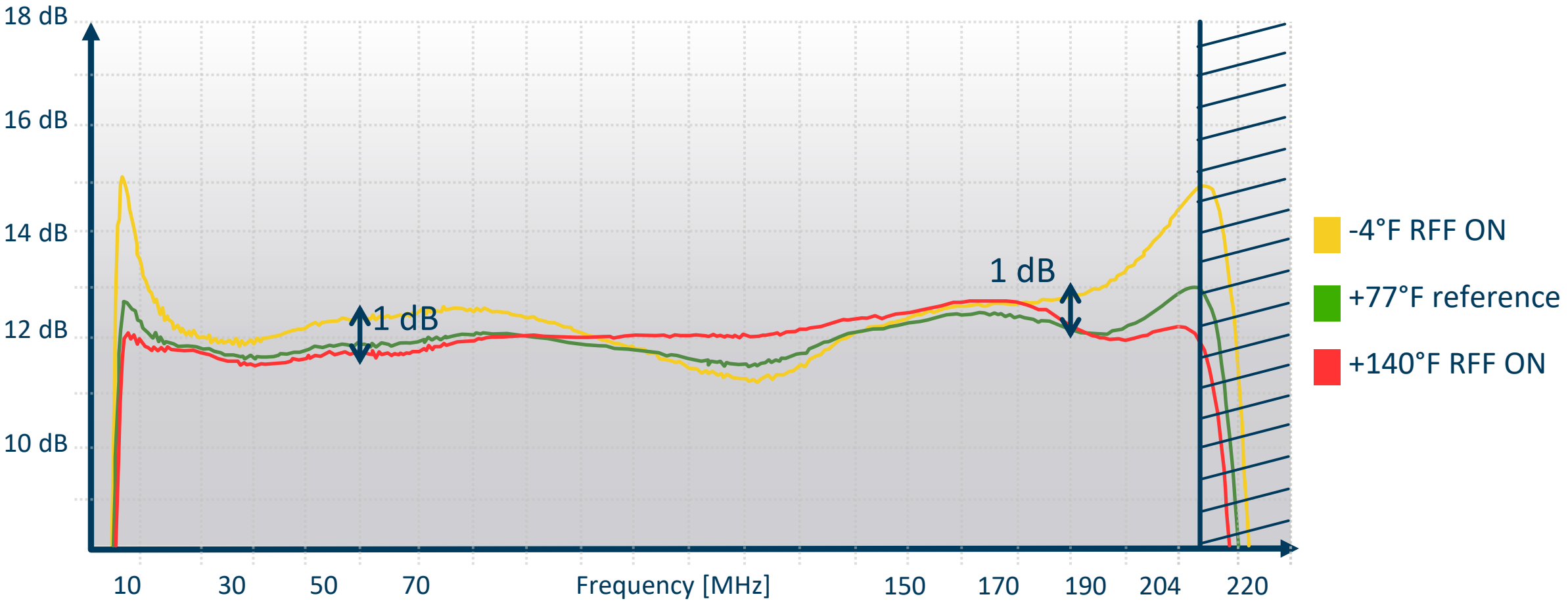
Return path slope

- Return Follows Forward (RFF) = Return path ALSC
- Return path ALSC has been used successfully in Europe together with 204 MHz upstream

Teleste Proprietary. All rights reserved.

Information Classification: General

Upstream frequency responses (RFF ON)



Teleste Proprietary. All rights reserved.

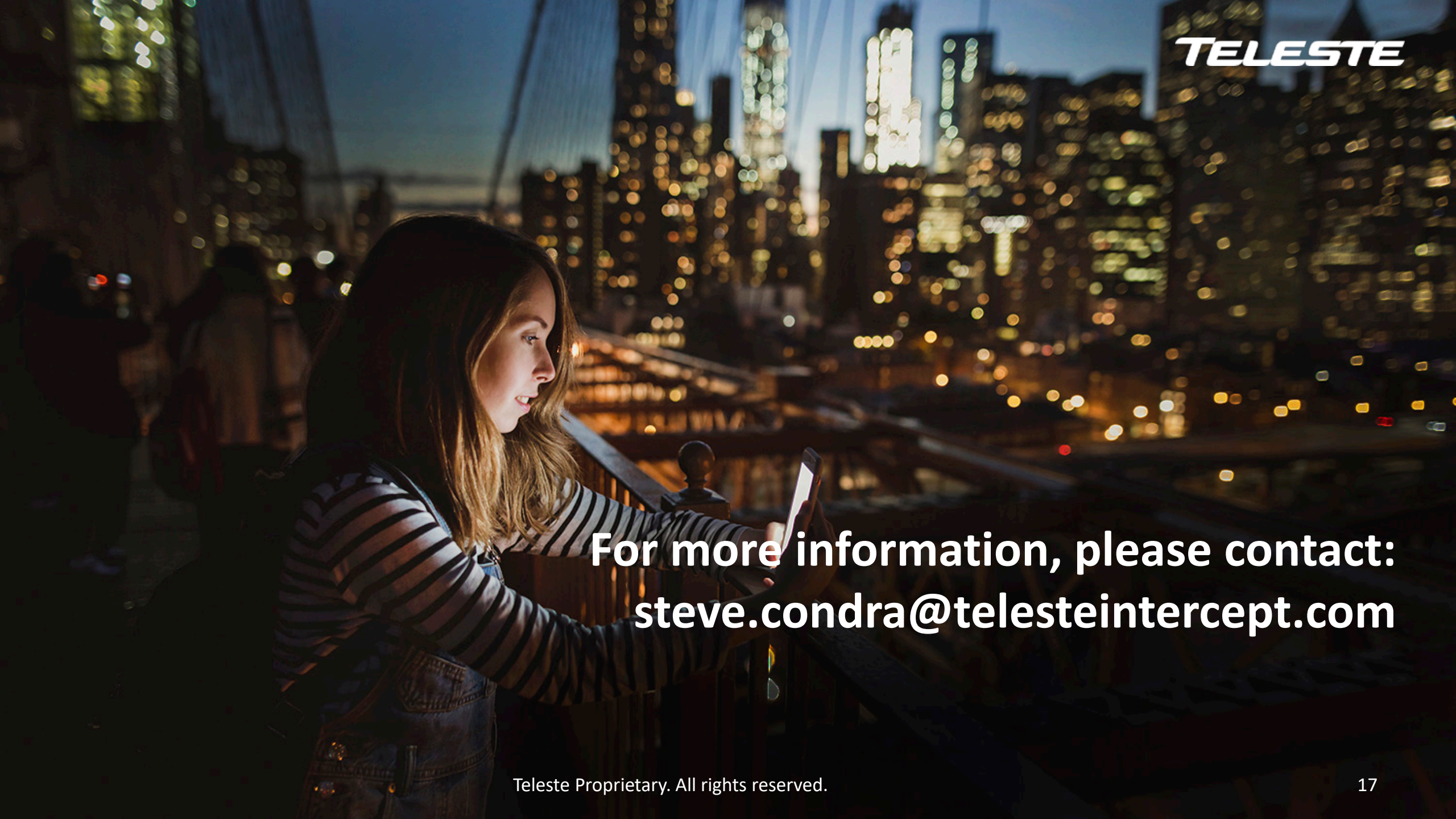
Information Classification: General

Summary

1. As upstream frequencies rise, **outdoor temperature changes** cause return path issues
2. Issues become visible above 100 MHz and **problematic above 204 MHz**
3. By following forward path changes (RFF), all seasonal maintenance visits **can be avoided**
4. More information / **results above 204 MHz** will be published at fall technical forum

Teleste Proprietary. All rights reserved.

Information Classification: General



TELESTE

For more information, please contact:
steve.condra@telesteintercept.com

Teleste Proprietary. All rights reserved.

Audience Poll I

When will the cable industry need to go beyond 1 Gig broadband speeds?

- Cable already needs to go beyond 1 Gig
- By the end of this year
- By the end of 2022
- By the end of 2023
- By the end of 2024
- No need

Information Classification: General

John J. Downey

Senior CMTS Technical Leader

SCTE · ISBE LIVELEARNING WEBINARS™ FOR PROFESSIONALS — IN PARTNERSHIP WITH — Light Reading

© Society of Cable Telecommunications Engineers, Inc. a subsidiary of CableLabs 2021 | scte.org

Information Classification: General

Path to Higher US Throughput

John J. Downey

Sr. CMTS Technical Leader

Cisco Systems

© 2011 Cisco and/or its affiliates. All rights reserved.

Prerequisites and Potential Issues

- DAA inevitable
  - High US spectrum on analog link = greater potential laser clipping
- Need to replace line equalizers, subscriber drop pads/EQs (whether standalone or in tap), and house amps
- Adjacent device interference (ADI) affects STB AGC & analog TV IF
  - Filters in house where needed just like MoCA
  - Gateway architecture
- Home passives can generate passive device intermodulation (PDI) distortion when hit with high US Tx
- FM-band & Off-Air Broadcast potential interference
- Leakage testing?

© 2010 Cisco and/or its affiliates. All rights reserved.
Information Classification: General

D3.1 - 204 MHz US Pros and Cons

- Pros
  - No special CMs, available to buy with programmable diplex
  - No special nodes with echo cancellation
  - No need for N+0
  - Can still achieve potentially 1.5 Gbps aggregate speed
  - DAA advantages along with no US laser clipping
- Cons
  - 204 MHz could be troublesome for N+3 or higher
  - Coax loss and temperature effects and no US AGC
  - Legacy STB OOB at 104 MHz, DACs at 75 MHz
  - Leakage testing at 138 MHz
  - FM carriage in European markets

© 2010 Cisco and/or its affiliates. All rights reserved.
Information Classification: General

D3.1 US Spectrum Thoughts

- Increasing US spectrum = more coax loss & tilt from CM to CMTS
  - US max Tx level issues
  - DRW violations (12 dB)
- More USs may lead to laser clipping
  - OFDMA even in 42 MHz may cause issues with AM link
  - 85 or 117 MHz may necessitate EDR (digital return) (A/D clipping?)
  - 204 MHz may necessitate DAA (Remote-PHY, FMA, …)
- No US ALC/AGC
  - Relying on CM/CMTS long-loop-level control and CM 12 dB DRW
  - Typical +/-2 dB swing @ 42 MHz (annual thermal fluctuations) w/ 4000’ coax
  - CMTS US level settings and adjustable range

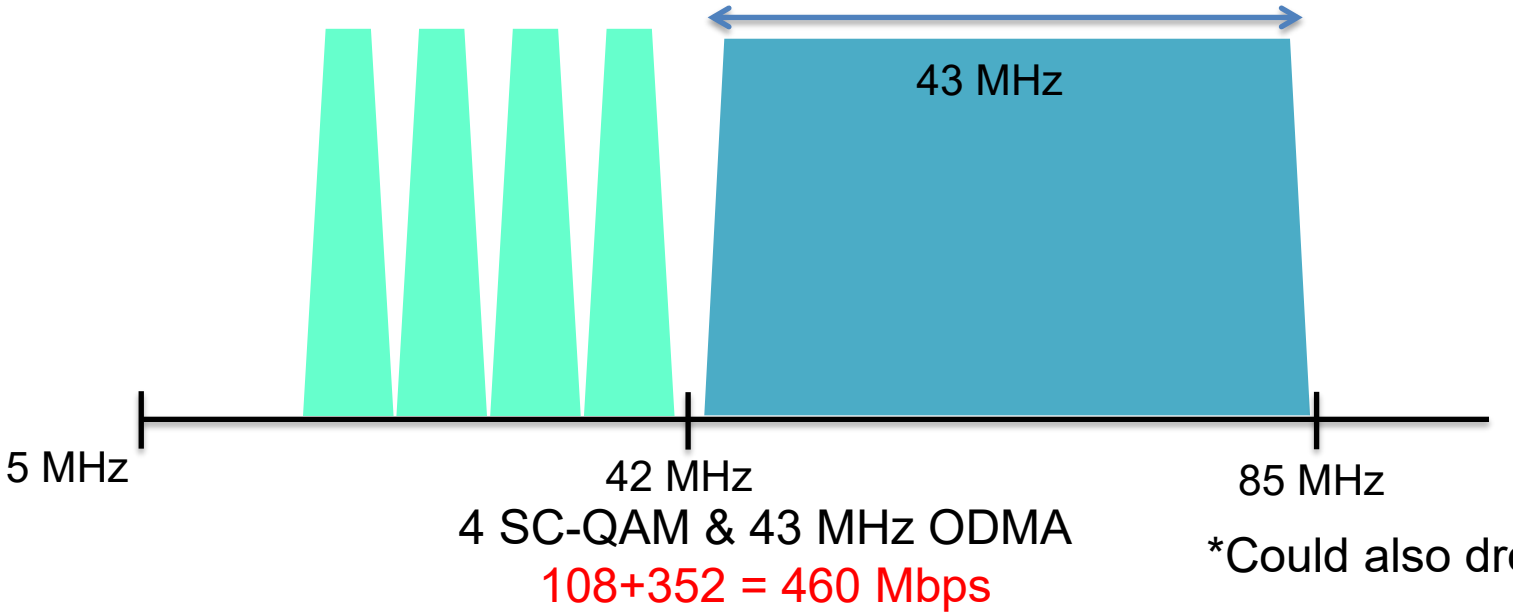
© 2010 Cisco and/or its affiliates. All rights reserved.
Information Classification: General

Potential Fixes for Higher US Freqs

- No Coax
- Conditioned taps - EQs & InvEQs for levels & DRW issues
  - Field Equalizers (FEQs) at least
  - EQ 5 MHz -1.2 GHz, no cutoff & grp delay or concern for diplex changes later
- Thermal issues
  - Underground cable
    - ✓ Passives still above ground
  - US thermal EQs to help stabilize negative fluctuations on cold days
    - ✓ Higher noise floor assuming aerial plant
  - Idea of US AGC driven by DS AGC circuitry or I-AMP
- D3.0 CM with Extended Pwr ECN = 54 dBmV max for 4-ch bonding
- D3.1 CM has ~ 5 dB more power per equivalent 8-ch D3.0 CM
  - D3.1 = 65 dBmV total avg power

© 2010 Cisco and/or its affiliates. All rights reserved.
Information Classification: General

D3.1 CMTS US Rx Example for 85 MHz

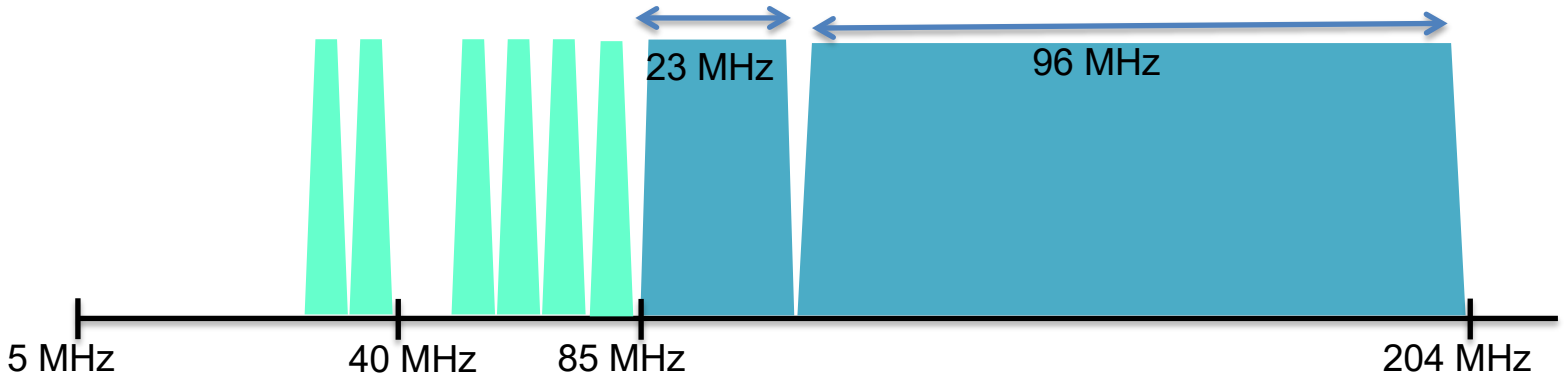


*Could also drop some ATDMA

Note: OFDMA level displayed on analyzer affected by amount of traffic; have seen where level does not match expected unless peak hold & send enough traffic to reach 70-90%

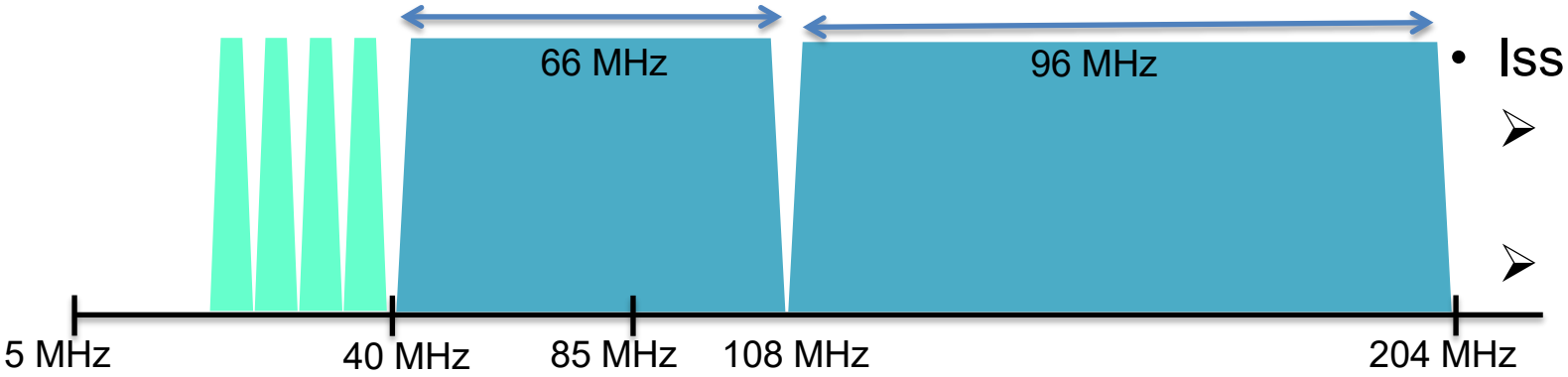
© 2010 Cisco and/or its affiliates. All rights reserved.
Information Classification: General

D3.1 CMTS US Rx Examples for 204 MHz



Example 1: 23 MHz & 96 MHz OFDMA

54+108+187+807 = 1156 Mbps



Example 2: 66 MHz & 96 MHz OFDMA

108+555+807 = 1470 Mbps

- Need to address CMs that support 42, 85 and 204 MHz in same plant
- Issues locking on correct US BG
  - ➢ Have smaller OFDMA from 42 to 85 & another above 85 to avoid concerns
  - ➢ Avoid FM band & just do 108-204
    - ✓ Then we lose 85-108 spectrum
- Working group looking at this and how to create partial mode scenario properly

© 2010 Cisco and/or its affiliates. All rights reserved.
Information Classification: General

D3.1 - 204 MHz Implementation Today

- Surgically place at MDUs
- Compact shelf with modularity provides
  - Multiple RF outputs (SGs) for risers in bldgs
  - Easy powering
  - Rack and stack
- CMs placed where needed
- Older CMs still work fine

© 2010 Cisco and/or its affiliates. All rights reserved.
Information Classification: General

Closing Points

- US AGC based on DS ALC possible - if necessary
  - I-node and i-amp could utilize auto-leveling
- Be aware of US temperature affects @ 204 MHz
  - Design 48 dBmV +/-3 dB for taps with < 25 dB of coax between RPD & tap, 46 +/-2 dB otherwise
- Fiber deep architectures with DAA will allow better performance and higher D3.1 modulation along with higher speeds
- Conditioned taps alleviate US power & tilt issues
  - Disparate SC-QAM US ch widths exacerbate D3.1 CM DRW issues
    - ✓ Get rid of narrow SC-QAMs in TCS
- Need to research ADI & PDI concerns
- Legacy devices will go through attrition leading to more efficiency
  - Drop SC-QAMs, add more OFDM on DS, & allocate more OFDMA on US

© 2010 Cisco and/or its affiliates. All rights reserved.
Information Classification: General

Asaf Matatyaou

VP, Solutions & Product Management
Harmonic

SCTE · ISBE LIVELEARNING WEBINARS™ FOR PROFESSIONALS — IN PARTNERSHIP WITH — Light Reading

© Society of Cable Telecommunications Engineers, Inc. a subsidiary of CableLabs 2021 | scte.org

Information Classification: General

10G or Bust
HFC & the Future Access Network

Asaf Matatyaou

VP, Product Management

July 15, 2021

©2021 Harmonic Inc. All rights reserved worldwide.

KEY TRENDS IMPACTING BROADBAND MARKET

harmonic

CONSUMPTION SURGING

Capacity and peak speed

SERVICE PROVIDER COMPETITION

5G and fiber

GOVERNMENT ENGAGEMENT

Regulatory intervention resulting in investment cycle (e.g., RDOF, municipal fiber, city carriers, European Green Deal)

NEWS

LightReading

US cable to face stiffer fiber competition as telcos get more aggressive →

FIERCE Telecom

AT&T eyes multi-gig move as part of fiber plan →

BROADBAND WORLD NEWS

US cable operators face rising fiber threat →

©2021 Harmonic Inc. All righ

• Information Classification: C

CABLE'S NEXT-GEN SOLUTION

harmonic

DENSIFICATION: FIBER DEEPER

- Multi-Gigabit DOCSIS
- Fiber to the Home (PON)
- Ethernet and Mobile Backhaul

DISAGGREGATION: DAA, VIRTUALIZATION

Scalability & Performance:

- Open, Best-of-Breed Choices
- Lower Cost, Space & Power

VALUE ADD SERVICES

- Higher QoE (Low Latency)
- Network & Service Analytics
- Edge Compute

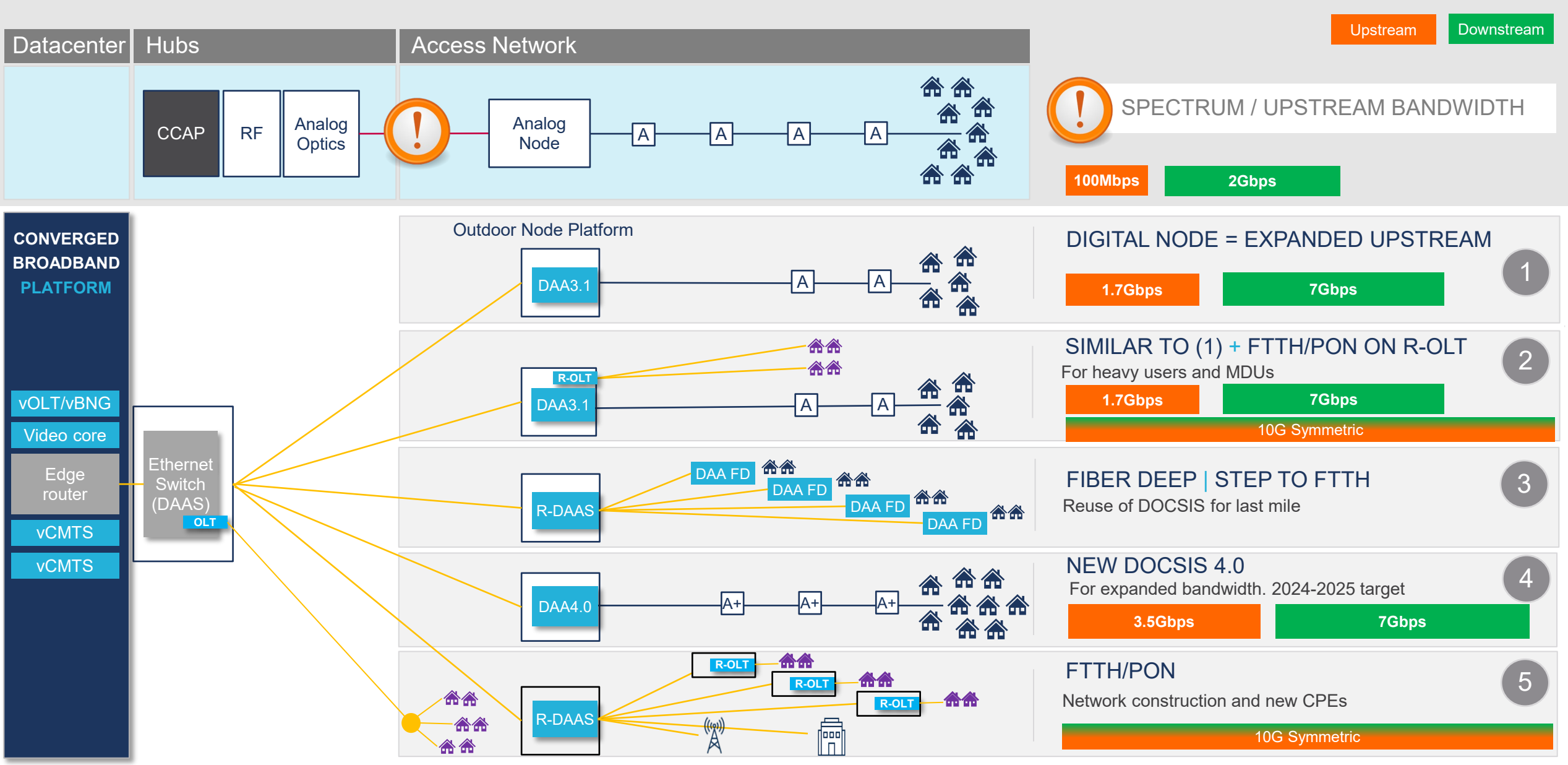
A CONVERGED BROADBAND PLATFORM

©2021 Harmonic Inc. All rights reserved worldwide.
Information Classification: General

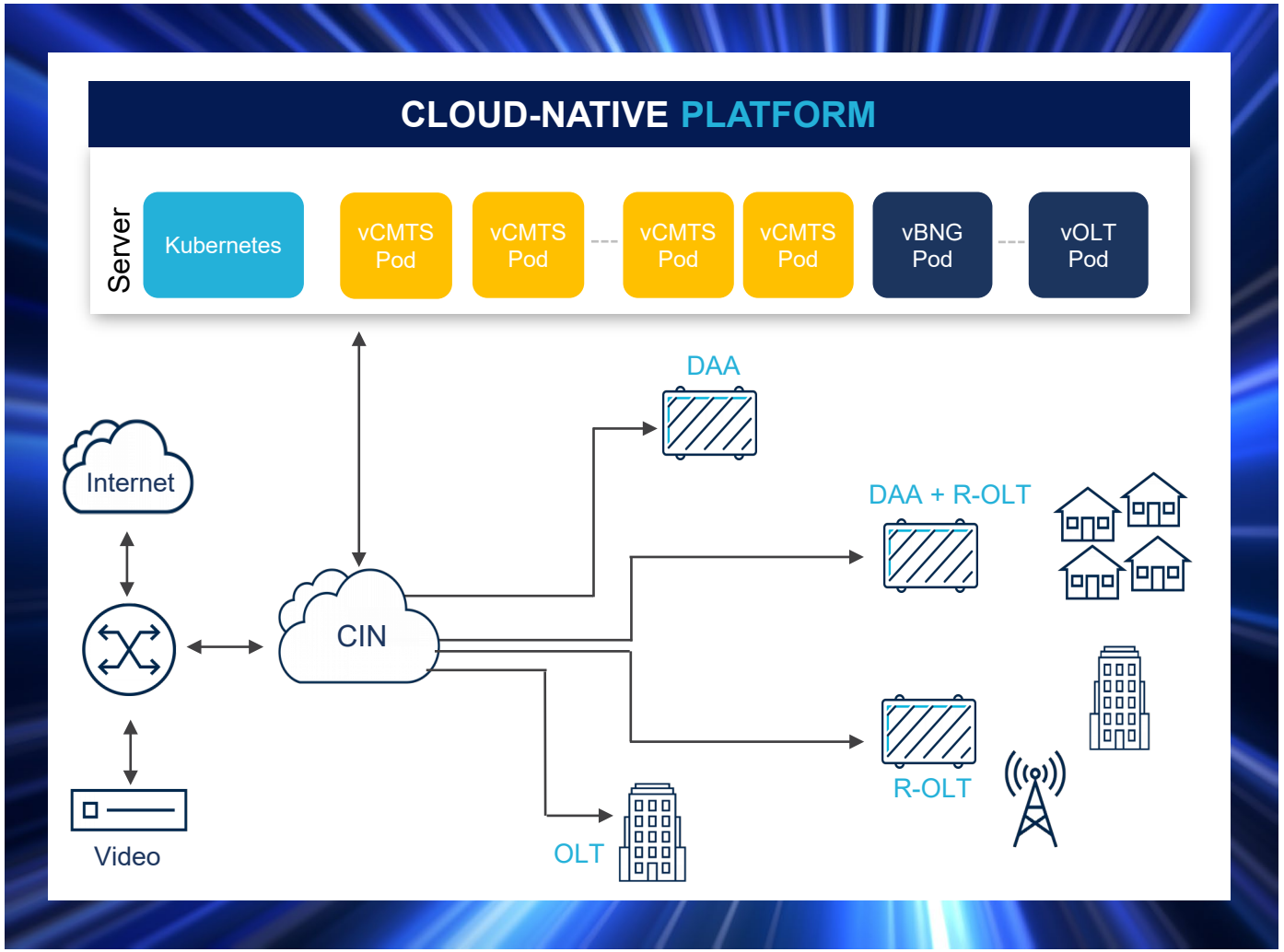
CABLE BROADBAND INVESTMENT STRATEGY

A PORTFOLIO OF OPTIONS

harmonic



CABLE / DOCSIS & FIBER / PON CONVERGENCE



MULTI-ACCESS EDGE

A single platform for simpler DOCSIS and PON operation

PON READY

Ethernet-based connectivity to remote devices

CLOUD-NATIVE BENEFITS

Scalability and performance

FEATURE VELOCITY

Leveraging common subscriber and traffic management capabilities

©2021 Harmonic Inc. All rights reserved worldwide.
Information Classification: General

10G

The Next Great Leap for Broadband

harmonic

SPEED

DAA

D3.1 DS, US (1+ Gbps)

PON (10 Gbps)

D4.0 Full Duplex (FDX)

D4.0 Extended Spectrum (ESD)

RELIABILITY

Proactive Network Maintenance

Fiber Deep

Disaggregation

Cloud-Native Virtualization

Connected Operation (AI/ML)

LATENCY

Low Latency DOCSIS

Low Latency Xhaul

Improved Gaming

VR QoE

Edge Compute

SECURITY

AI/ML/Anomaly Detection

Isolate/Prevent Threats

Cable and Home Networks

IoT Services

©2021 Harmonic Inc. All rights reserved worldwide.
Information Classification: General

CLOUD-NATIVE VIRTUALIZATION
10G NETWORK TRANSFORMATION

harmonic

Speed
- Runs on COTS servers with 100Gbps NICs
- 1 Gbps+ symmetric services with vCMTS
- 10 Gbps symmetric services with vPON

Reliability
- Improve service uptime for mission critical services
- Smaller operating domains with reduced failover times
- Predict/react to network issues faster

Security
- Software is the defense to quickly adapt and deflect new security threats

Latency
- Deliver best qualify of experience for “real-time” experiences, such as gaming and AR/VR

Future Proof
- Adapt to future requirements with software upgrades

©2021 Harmonic Inc. All rights reserved worldwide.
Information Classification: General

harmonic

THANK YOU.

©2021 Harmonic Inc. All rights reserved worldwide.

Audience Poll II

When do you plan to deploy PON with DOCSIS in your HFC network?

- In the next year
- In the next 1 to 3 years
- In the next 3 to 5 years
- More than 5 years from now
- No plans to deploy PON

Information Classification: General

Dean Stoneback

Senior Director

Engineering & Standards

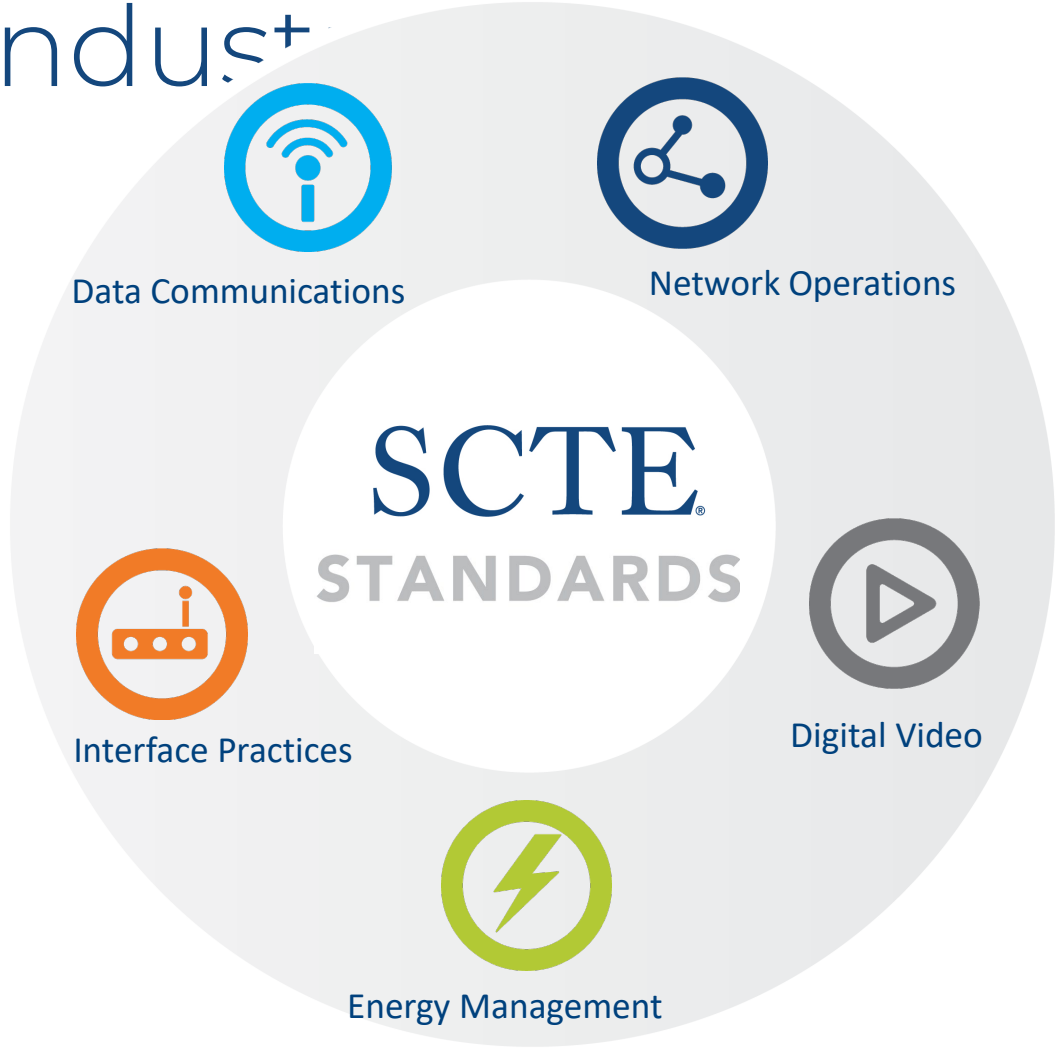
SCTE

SCTE · ISBE LIVELEARNING WEBINARS™ FOR PROFESSIONALS — IN PARTNERSHIP WITH — Light Reading

© Society of Cable Telecommunications Engineers, Inc. a subsidiary of CableLabs 2021 | scte.org

Information Classification: General

SCTE's Award Winning Standards Are Leading the Cable Telecommunications Indust



THE ONLY ANSI-ACCREDITED program in the cable industry

OVER 300 SCTE standards and operational practices approved by ANSI.

STANDARDS RECENTLY RATED IN THE TOP 10 among ANSI-accredited Standards developing orgs.

Organization-based program with **OVER 140** member organizations.

Top service providers and **OVER 1,100** subject matter experts.

Join at scte.org/standards-join

© Society of Cable Telecommunications Engineers, Inc. a subsidiary of CableLabs 2021 | scte.org

10G Initiatives in the SCTE Standards Program

RELIABILITY

- Reliable network powering (EMS)
- Proactive network maintenance (NOS)
- Measurement practices (NOS)
- Business continuity / disaster recovery (NOS)
- Human impact on network operations (NOS)

SECURITY

- Artificial intelligence / machine learning (DSS)

SPEED

- 3 GHz actives and passives (IPS)
- Generic Access Platform (IPS)

LATENCY

- Edge computing inside the Generic Access Platform (IPS)

10G Powered by ncta CableLabs Cable Europe SCTE·ISBE

Join at scte.org/standards-join

EMS = Energy Management Subcommittee
NOS = Network Operations Subcommittee
DSS = Data Standards Subcommittee
IPS = Interface Practices Subcommittee

© Society of Cable

Standards Supporting Extended Spectrum

3 GHz Task Force

- Evaluate all IPS Standards to determine how to best update them to match the DOCSIS 4.0 specifications.
  - Standardized text to be used in IPS standards
  - Standardized approaches such as specification tiering or the creation of equipment “classes” so that both legacy and future equipment can be accommodated

1.8 / 3.0 GHz Hardline Taps and Passives

- Created standards for 1.8 / 3.0 GHz taps and passives including:
  - Mechanical specifications and requirements for electrical performance
  - 1.8 GHz faceplate and 3 GHz housing
  - For taps: RF bypass mode that maintains AC and RF through housing when faceplate is removed
- SCTE 264 2020: Broadband Radio Frequency Hardline Taps for Cable Systems
- Coming soon: SCTE 265 Broadband Radio Frequency Hardline Passives for Cable Systems

SCTE
Information Classification: General

Standards Supporting Extended Spectrum

1.8 GHz Amplifiers – Being Developed Now – Get Involved

- Traditional bandwidth expansion approach
  - Adds additional 600 MHz of spectrum beyond today's state-of-the-art amplifiers
- Supports higher upstream speed by standardizing higher frequency upstream/downstream splits (204, 300, 396, 492 MHz, etc.)
- Provides prospective equipment vendors with guidance that will help them to design and manufacture standardized products to support full utilization of DOCSIS 4.0 in the network
- Standards-based product development helps ensure that products meet the needs of [illegible] les multi-vendor e[illegible]

Chairs & Vice Chairs:	Dedicated Authors:
David Job, Cox Greg Kueneman, Shaw Nick Segura, Charter	Mike Whitley, ATX Steve Condra, Teleste

Join at scte.org/standards-join

© Society of Cable Telecommunications Engineers, Inc. a subsidiary of CableLabs 2021

SCTE
CABLE-TEC EXPO®
FAST FORWARD 2021

UNLEASH THE POWER OF LIMITLESS CONNECTIVITY

OCTOBER 11-14
ATLANTA, GA

WE'VE UNLEASHED THE POWER...

2021 PROGRAM CHAIR:

Kevin Hart
EVP, Chief Product & Technology Officer,
Cox Communications

POWERHOUSE General Session KEYNOTES:

Eric Yuan
Founder & CEO,
Zoom Video
Communications, Inc.

Wendell Weeks
Chairman & CEO,
Corning, Inc.

#cabletecexpo
expo.scte.org

Audience Q & A

Alan Breznick
Cable/Video Practice Leader
Light Reading

Dean Stoneback
Senior Director of
Engineering & Standards
SCTE

Steve Condra
R&D and Product
Management
Teleste Intercept

John J. Downey
Senior CMTS
Technical Leader
Cisco Systems

Asaf Matatyaou
VP. Solutions &
Product Management
Harmonic

Information Classification: General
© Society of Cable Telecommunications Engineers, Inc. a subsidiary of CableLabs 2021 | scte.org

Next Months Webinar

Tapping Into the Cloud

8/19/2021 11:00 am New York / 8:00 am Los Angeles

This educational series is a member benefit in partnership with LightReading. SCTE's LiveLearning Webinars™ for Professionals is a series of live, interactive, web-based seminars that occur the third Thursday of every month.

Register for next month's webinar, the 2021 webinar series or access previously recorded sessions at www.scte.org/LiveLearning.

Information Classification: General
© Society of Cable Telecommunications Engineers, Inc. a subsidiary of CableLabs 2021 | scte.org

THANK YOU!

LiveLearning Webinars™ For ProfessionalS

ENVISIONING THE FUTURE OF CONNECTIVITY, TODAY.

SCTE a subsidiary of CableLabs® | LIVELEARNING WEBINARS™ FOR PROFESSIONALS

IN PARTNERSHIP WITH Light Reading

© Society of Cable Telecommunications Engineers, Inc. a subsidiary of CableLabs 2021 | scte.org

Information Classification: General

LIVE! LightReading WEBINAR

Thank you for attending!

Upcoming Light Reading webinars

www.lightreading.com/webinars.asp

Information Classification: General