Extending the Spectrum

LiveLearning Webinar™ For Professionals

Thursday, March 26, 2020
11:00 am – 12:00 pm ET

PARTICIPATING COMPANIES:

CableLabs  COGECO  Mediakom

IN PARTNERSHIP WITH LightReading
TODAY’S SPEAKERS

Alan Breznick
Contributing Analyst
Heavy Reading

Dean Stoneback
Senior Director
Engineering
SCTE.ISBE

Doug Jones
Principal Architect
CableLabs

Robin Lavoie
Senior Director
Network Evolution Strategies
Cogeco

Colin Howlett
VP, Architecture
Vecima

JR Walden
CTO & SVP
Mediacom
AGENDA

• Light Reading—DOCSIS 3.1® Status Report, 10G Push
• CableLabs—DOCSIS® 4.0 FDD Technology
• Cogeco—Planning HFC Networks Evolution
• Vecima—Equipment Upgrades over Plant Redesign
• Mediacom—Looking to the Future
• SCTE—Tech Standards, Training & Certifications
• Audience Q&A
## Most Larger NA MSOs Have Rolled Out DOCSIS 3.1

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<tr>
<th>MSOs</th>
<th>Deployments</th>
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<tr>
<td>Comcast</td>
<td>Now offers DOCSIS 3.1 to virtually whole footprint after completing rollout in Oct. 2018</td>
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<td>Charter Communications</td>
<td>Now offers D3.1 to about 95% of its footprint; aimed to wrap up rollout by end of 2018</td>
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<td>Cox Communications</td>
<td>Now offers D3.1 to over 50% of its footprint; plans to reach 99% coverage by end of 2019</td>
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<td>Altice USA</td>
<td>Despite plans to build FTTH networks, now quietly rolling out D3.1 in New York area</td>
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<td>Mediacom Communications</td>
<td>One of the first MSOs to deploy D3.1, it now offers service to virtually all its footprint</td>
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<td>Shaw Communications</td>
<td>Now offers D3.1 service to virtually all its Canadian homes, using Comcast’s Xb6 modems</td>
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<td>Midco</td>
<td>Another early D3.1 adopter, it now offers service to over 90% of its footprint</td>
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<td>WOW</td>
<td>Has now rolled out D3.1 to at least 95% of its footprint</td>
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<tr>
<td>Rogers Communications</td>
<td>Now offers D3.1 service to virtually all its Canadian homes, using Comcast’s Xb6 modems</td>
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<td>Cable One</td>
<td>Now offers 1-Gig service to 95% of footprint; but relying solely on D3.0, not D3.1</td>
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<td>RCN</td>
<td>Offers D3.1 in all legacy markets; now upgrading former Wave Broadband markets</td>
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<td>Atlantic Broadband</td>
<td>Has rolled out DOCSIS 3.1 to 90% of its footprint</td>
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<td>BCI</td>
<td>Now offers D3.1 to 99.9% of homes in footprint</td>
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<td>Videotron</td>
<td>Has broadly deployed DOCSIS 3.1 throughout its Quebec markets</td>
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<td>Cogeco Connexion</td>
<td>Now offers D3.1 service Has to 60% of its Ontario and Quebec homes</td>
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<td>MSO</td>
<td>Deployments</td>
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<td>Liberty Global</td>
<td>Plans to offer DOCSIS 3.1 service to its nearly 15 million UK homes by the end of 2021, after starting with Southampton and Manchester launches this fall</td>
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<td>Vodafone</td>
<td>Launched D3.1 in four Bavarian cities in fall 2018, covering 400,000 homes; aims to offer service to 13 million German homes by the end of 2020</td>
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<td>Com Hem (Tele2)</td>
<td>Has upgraded most of its HFC network in Sweden for D3.1, with many small sites left</td>
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<td>Stofa</td>
<td>Has now deployed D3.1 and DAA to 60% to 65% of its 400,000-home network in Denmark, with plans to reach 90% to 95% coverage by spring 2021</td>
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<td>TDC</td>
<td>Planned to complete rollout of D3.1 in Denmark by the end of 2018</td>
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<td>NOS</td>
<td>Has completed full network upgrade to D3.1 in Portugal and developed D3.1 routers</td>
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<td>Telenet</td>
<td>Started rolling out D3.1 service in Belgium in Sept. 2019</td>
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<td>Eltrona</td>
<td>Launched D3.1 service in Luxembourg in September 2018</td>
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<td>Melita</td>
<td>Completed upgrading its Malta network to D3.1 in April 2019</td>
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And 10G is Coming Soon

- Brand introduced at CES 2019.
- It’s Trademarked!
- Speed target: Symmetrical 10 Gbit/s
- Lower latency, improved security.
- Multiple technologies involved – PON, FDX, ESD, Wireless?
SCTE·ISBE Live Learning Webinar: Extending the Spectrum
DOCSIS® 4.0 FDD Technology
March 26, 2020

Doug Jones | Principal Architect
d.jones@cablelabs.com
10 Gigs on the Horizon

- SCTE
- NCTA
- CableLabs

Source: https://www.nngroup.com/articles/law-of-bandwidth/
Coax has a long way to go
Coax has a long way to go
We have done it again
The DOCSIS Cable Modem. Since 1996, a rewarding project to be on.
DOCSIS 4.0 Paths

1. Extended Spectrum DOCSIS
   - More upstream with flexible upstream splits, and more downstream

2. FDX (Full Duplex)
   - Full duplex operation, upstream and downstream in the same spectrum
   - As well as traditional downstream spectrum
   - SCTE Live Learning Events on: 8/17/16; 6/21/18; 5/16/19
Why Extend the Spectrum
Why Extend the Spectrum

Capacity is related to spectrum
Why Extend the Spectrum

Capacity is related to spectrum

In yester-year, the spectrum was expanded to carry more TV channels.
Why Extend the Spectrum

Now DOCSIS is doing the same
Why Extend the Spectrum

Now DOCSIS is doing the same

Initially DOCSIS spectrum grew to 192 MHz (32 QAMs)
- DOCSIS 1.0, 2.0 and 3.0
Why Extend the Spectrum

Now DOCSIS is doing the same

Initially DOCSIS spectrum grew to 192 MHz (32 QAMs)
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Then DOCSIS spectrum grew to 576 MHz
- DOCSIS 3.1 – 32 QAMs and 2 OFDM – enough for a 5 Gbps downstream
DOCSIS 3.1 CM
5 Gbps speed test results
Why Extend the Spectrum

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- DOCSIS 1.0, 2.0 and 3.0

Then DOCSIS spectrum grew to 576 MHz
- DOCSIS 3.1  –  32 QAMs and 2 OFDM  –  enough for a 5 Gbps downstream taking into account the LDPC FEC, Cyclic Prefix, Ethernet & IP overheads, etc.
Why Extend the Spectrum

Now DOCSIS is doing the same

Initially DOCSIS spectrum grew to 192 MHz (32 QAMs)
- DOCSIS 1.0, 2.0 and 3.0

Then DOCSIS spectrum grew to 576 MHz
- DOCSIS 3.1 – 32 QAMs and 2 OFDM – enough for a 5 Gbps downstream

And now, DOCSIS 4.0 has enough spectrum for 10 Gbps downstream
Why Extend the Spectrum

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Then DOCSIS spectrum grew to 576 MHz
- DOCSIS 3.1 – 32 QAMs and 2 OFDM – enough for a 5 Gbps downstream

And now, DOCSIS 4.0 has enough spectrum for 10 Gbps downstream
And to do that, the spectrum needs to be extended.
So what is going on?

1. New top end for cable plant – 1,794 MHz – more spectrum, more speed

2. New Diplex filters for more upstream (flexible choices)

3. SCTE working groups for 1.8 GHz and 3.0 GHz

4. Other Considerations
   a) Distributed CMTS Architecture
   b) Point of Entry Modem
New top end

- The top end of the cable is now 1,794 MHz

- The D3.1 top end is 1,218 MHz
  - 1,794 MHz is 3 more OFDM channels (at 192 MHz each)

- The foundation for DOCSIS 4.0 is the same DOCSIS 3.1 technology
  - Orthogonal Frequency Division Multiplexing (OFDM)
  - Orthogonal Frequency Division Multiple Access (OFDMA)
  - SCTE and local chapters have training
### New Diplex Filters

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<thead>
<tr>
<th>Split</th>
<th>Start (MHz)</th>
<th>Stop (MHz)</th>
<th>Filter width (MHz)</th>
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<tbody>
<tr>
<td>Low split</td>
<td>42</td>
<td>54</td>
<td>12</td>
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<tr>
<td>Mid split</td>
<td>85</td>
<td>102</td>
<td>17</td>
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<tr>
<td>High split</td>
<td>204</td>
<td>258</td>
<td>54</td>
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**Today**
# New Diplex Filters

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<td>204</td>
<td>258</td>
<td>54</td>
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<td></td>
<td>300</td>
<td>372</td>
<td>72</td>
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<td></td>
<td>396</td>
<td>492</td>
<td>96</td>
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<tr>
<td>New</td>
<td>492</td>
<td>606</td>
<td>114</td>
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<tr>
<td></td>
<td>684</td>
<td>834</td>
<td>150</td>
</tr>
</tbody>
</table>

Today

Low split

Mid split

High split

New
# New Diplex Filters

<table>
<thead>
<tr>
<th>Start (MHz)</th>
<th>Stop (MHz)</th>
<th>Filter width (MHz)</th>
<th>Forward spectrum available (MHz)</th>
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<tbody>
<tr>
<td>42</td>
<td>54</td>
<td>12</td>
<td>X</td>
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<tr>
<td>85</td>
<td>102</td>
<td>17</td>
<td>1,686</td>
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<tr>
<td>204</td>
<td>258</td>
<td>54</td>
<td>1,536</td>
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<tr>
<td>300</td>
<td>372</td>
<td>72</td>
<td>1,422</td>
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<td>396</td>
<td>492</td>
<td>96</td>
<td>1,302</td>
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<td>492</td>
<td>606</td>
<td>114</td>
<td>1,188</td>
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<tr>
<td>684</td>
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<td>150</td>
<td>960</td>
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Visualization

696 MHz
• More Upstream – multigigabit
• More Downstream – up to 10 Gbps
• New service tiers – symmetric multigigabit
1. **1.8 GHz and 3.0 GHz Actives and Passives (update existing / develop new)**
   - Cable performance
   - Connector performance
   - Shielding effectiveness
   - Feeder and drop passives and actives
   - Measurement methods and test procedures
   - Hardline passives (couplers, splitters, and power inserters)
   - Hardline taps

2. **New standard for 3.0 GHz hardline tap housing**
   - Mechanical specifications, including sizes, mounting points, faceplate interfaces and mounting, RF connectors and seizure mechanisms
   - Requirements for electrical performance
   - An RF bypass mode that maintains AC and RF through the housing when the faceplate is removed, including RF performance specifications for bypass mode
Additional Items

To provide the best possible signal to the modem out to 1,794MHz

1. Distributed CMTS Architecture (DCA)
   - Flexible MAC Architecture (FMA a.k.a. R-MACPHY)
   - Remote PHY (R-PHY)
     - Digital fiber provides the best possible signal at the launch node, which provides best possible signal at end of line

2. Point of Entry modem
   - No splitting loss in the home
   - Implies an all broadband service offering
Closing

- Operators modeled existing plant
  - For originally designed 550 MHz plant, should be a drop-in

- The 1.8 GHz ecosystem is developing
  - Passives – available now
  - Actives – SCTE Expo is the place to be (Denver, 13-16 October)
  - Coax – has always been good to go, and can go further

- DOCSIS 4.0 includes options for operators
  - Extended Spectrum
  - Full Duplex
SCTE·ISBE Live Learning Webinar: Extending the Spectrum
DOCSIS® 4.0 FDD Technology

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cablelabs.com
Planning HFC Networks Evolution

Robin Lavoie
Senior Director, Network Evolution Strategies
Overall Objectives

- **Support growing Internet usage and speed - Upstream and Downstream**
  - Optimize capital investment
  - Use a financial model to select the right tool to use at the right time

- **Avoid future labor cost**
  - Do it right when we touch the network, having a future vision in mind
  - Adopt FTTH architecture for the deployment of any new fiber cable
  - Deploy remote configurable/troubleshooting active equipment

- **Slow evolution to FTTH over 10 to 20 years**
  - Gradual deployment of FTTH
  - Co-existence with HFC Networks
Upgrading to 1.8 GHz - Some Technology Options

● **Amplifiers**
  ○ High gain or Low gain (aka Booster)
  ○ Diplex, no-Diplex, or Echo cancellation
  ○ Remote control, monitoring, integrated full band capture (PNM)

● **Passives**
  ○ Will we expand spectrum to 3 GHz, all the way to the CPE; or
  ○ Will we expand spectrum to higher frequency but only between amplifiers

● **Nodes**
  ○ Deploy new DAA node as networks are upgraded to 1.8 GHz; or
  ○ Keep the existing node until new spectrum is exhausted

● **Fibre**
  ○ Get ready for future FTTH
Some Evolution Scenarios

- ESD 1.8 GHz Excluding Node
- Upgrade Node to DAA
- Node Split
- Node Split
- FTTH Migration

- ESD 1.8 GHz Including Node
- Node Split
- ESD 1.8 GHz Including Node
- FTTH Migration

- Calculate NPV Per Individual Scenario
# Running Scenarios - Example

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Triggers</th>
<th>Action-1</th>
<th>Action-2</th>
<th>Action-3</th>
<th>Action-4</th>
<th>Action-5</th>
<th>HP</th>
<th>Cost1/hp</th>
<th>Cost2/hp</th>
<th>Cost3/hp</th>
<th>Cost4/hp</th>
<th>NPV10</th>
<th>NPV12</th>
<th>NPV14</th>
<th>NPV16</th>
<th>Rk...</th>
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<td>ESD12-ESD18-SPLIT-10GEPON</td>
<td>U-D-D</td>
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## Analysis - Example of Potential Results

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<tr>
<th>Scenario</th>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
<th>NPV</th>
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<tbody>
<tr>
<td>1</td>
<td>Node Split from 300 HP</td>
<td>Node Split from 150 HP</td>
<td>Node Split from 75 HP</td>
<td>Node Split from 37 HP</td>
<td>4X</td>
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<tr>
<td>2</td>
<td>RF Upgrade to 1 GHz</td>
<td>Node Split from 300 HP</td>
<td>Node Split from 150 HP</td>
<td>Node Split from 75 HP</td>
<td>2X</td>
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<tr>
<td>3</td>
<td>RF Upgrade to 1 GHz</td>
<td>Node Split from 300 HP</td>
<td>Node Split from 150 HP</td>
<td>Start Migration to FTTH</td>
<td>1.5X</td>
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</table>
HFC Networks Potential Evolution

Nodes

Sizes
Thank You

Robin Lavoie
Senior Director, Network Evolution Strategies
EXTENDING THE SPECTRUM

SCTE-ISBE LIVE LEARNING WEBINAR

COLIN HOWLETT
VP ARCHITECTURE
EXTENDED SPECTRUM — HOW DO WE GET THERE?

Evolution not revolution
N+x rather than N+0

Keep existing amp spacings

Focus on equipment upgrades over coax plant redesign
1.8 GHz plant passives becoming available

SCTE IPS 3 GHz housing standardization a strong long term approach to reduce vendor lock-in

Locations with signal conditioning taps need special attention – how do you handle split migration?

Start seeding into network whenever appropriate
PLANT DOWNSTREAM LEVELS

Drop down to keep total composite power reasonable (+70 dBmV)

Drop down frequency could be operator-specific but align with OFDM channel boundaries

Flexible shaping to optimize capacity and reach for plant

<1 GHz levels stay the same to keep existing amp spacings

<table>
<thead>
<tr>
<th>Frequency [MHz]</th>
<th>RF Output Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>1700</td>
</tr>
<tr>
<td>400</td>
<td>1200</td>
</tr>
<tr>
<td>1200</td>
<td>400</td>
</tr>
<tr>
<td>1700</td>
<td>200</td>
</tr>
</tbody>
</table>

- Operator 1 N+x
- Operator 2 N+x
- Typical 1 GHz N+0
- Tilt-Flat
1.8 GHz amplifiers not available yet
   Early hybrid amplifier silicon in vendor review

Housing upgrades needed

Software switchable diplexers for easy field migration

Is it the right time to consider “smart” amplifiers?
   Integrated DOCSIS CM for PNM
   Remote RF controls for end-end system optimization
Housings and upgradeability

- Old nodes need upgrades for high frequency
- Carefully consider nodes now which can support field upgrade to 1.8 GHz

DAA using RPD or RMD is a key enabler

- Assumed DAA-only in DOCSIS 4.0 specifications
- Start DAA well ahead of 1.8 GHz to get benefits now and learn DAA operations
Node splits expected to be needed with organic N+x migration
Minimize unnecessary construction with software-segmentable nodes

Ethernet optics – build the CIN for dual 10G or save wavelengths with 25G?
SPECTRUM MIGRATION – MULTI-PHASE APPROACH

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>85/108</td>
<td>1002</td>
<td>0.44</td>
<td>8.6</td>
</tr>
<tr>
<td>204/258</td>
<td>1218</td>
<td>1.40</td>
<td>9.2</td>
</tr>
<tr>
<td>300/372</td>
<td>1410</td>
<td>2.16</td>
<td>10</td>
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<tr>
<td>396/492</td>
<td>1602</td>
<td>2.93</td>
<td>10.7</td>
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<tr>
<td>492/606</td>
<td>1794</td>
<td>3.70</td>
<td>11.1</td>
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<tr>
<td>684/834</td>
<td>1794</td>
<td>5.24</td>
<td>9.2</td>
</tr>
</tbody>
</table>

- **DOCSIS 3.1 Starting Point**
  - Starting at 85 MHz or 204 MHz with DOCSIS 3.1
  - First upgrade if low split today

- **DOCSIS 4.0 US Upgrade 1**
  - 85 to 300 MHz or 204 to 396 MHz
  - Adds multi-gig US and extended DS frequencies
  - Likely combined with IP video as primary or all-IP

- **DOCSIS 4.0 US Upgrade 2**
  - Move to 492 or 684 MHz for maximum HFC US
  - 192 MHz incremental DS upgrades until full 1794 MHz needed
  - 1218 -> 1410 -> 1602 -> 1794 MHz

- **US**: 18-42 MHz (100 Mbps), OFDMA at 8 bps/Hz
- **DS**: 6 x 192 MHz OFDM at 9.6 bps/Hz

Confidential & Proprietary Information
Common implementation today
Requires coordinated field work for any split transitions

Drastically reduce guard band using echo/noise cancellation
Potential higher US noise floor
CMs likely diplexed anyway so limited gain

Support A/B pluggable diplexers
Trigger switch remotely
- FSK or DOCSIS for amps
- In-band for RPD/RMD
Install third diplexer anytime after first switch
Extended spectrum can use the N+x plant you have by adding:

Passives as needed – 1.8 GHz now and 3 GHz standardized housings to come

Amplifiers – consider software-switchable diplexers and smart monitoring

Nodes – RPD/RMD built for 1.8 GHz while considering software-switchable diplexers and software-based segmentation
Thank You

EXTENDING THE SPECTRUM

COLIN HOWLETT, VP ARCHITECTURE

ENTRA
Dean Stoneback
Director of Engineering
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Interface Practices Subcommittee (IPS) 
Generic Access Platform (GAP)

- Project supported by Charter, Cox, Shaw, and others
  - Physical, thermal, mechanical, and electrical interfaces for the internals of a node housing
  - Allows OEMs to devote their value-adding efforts to the service-generating modules that reside inside the enclosure
  - Any module that is compliant with the GAP specification will be able to coexist with other GAP-compliant modules
- Group Chairs: Kevin Kwasny and Roger Stafford, Charter Communications
- Meeting Schedule: Bi-Weekly, Wednesday at 3:00 p.m. ET, plus many weekly breakout sessions
- Join at scte.org/standards-join
Interface Practices Subcommittee (IPS)
3 GHz Task Force

Group Charter

• The purpose of the 3.0 GHz Task Force is to evaluate all IPS Standards to determine how to best update them to match the DOCSIS 4.0 specifications.
• The task force creates standardized text to be used in IPS standards and standardized approaches such as specification tiering or the creation of equipment “classes” so that both legacy and future equipment can be accommodated.
• The identified standards are then updated.
• Group Chair: Timothy Cooke, Director of Technology, Amphenol Broadband Solutions
• Meeting Schedule: Bi-weekly, Monday at 4:00 p.m. ET
• Join at [scte.org/standards-join](http://scte.org/standards-join)
Interface Practices Subcommittee (IPS)  
WG2 DG1 - 3 GHz Hardline Taps and Passives

Group Charter

- Create standard(s) for 3.0 GHz taps including:
  - Housing and faceplate specifications that enable interoperable faceplate replacements while allowing for vendor differentiation
  - Mechanical specifications, including sizes, mounting points, and faceplate interfaces and mounting
  - Requirements for electrical performance
  - An RF bypass mode that maintains AC and RF through the housing when the faceplate is removed, including RF performance specs for bypass mode
- The group should also consider creating standard(s) for hardline passives.
- Group Chair: Nick Segura, Advanced Engineering Principal Engineer, Charter Communications
- Meeting Schedule: Weekly, Tuesday at 11:00 a.m. ET
- Join at scte.org/standards-join
Interface Practices Subcommittee (IPS)
3 GHz Coordination

Key RF Connectors Are Being Updated

• GAP, tap and 3 GHz teams are working together to update common standards
• F connector updates
  • SCTE 01 and SCTE 02 female ports
  • SCTE 123 and SCTE 124 male connectors
  • Many others
• 5/8-24 RF & AC equipment port updates
  • SCTE 91 and SCTE 92 female port and male connector
  • Considering a standard on the length of the male connector
• Join at scte.org/standards-join
SCTE•ISBE Training

For more information and to register go to: scte.org/courses

Course
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• DOCSIS® 3.1 Essentials

Certification
• DOCIS Engineering Professional

Resource:
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