CABLE-TEC EXPO'13
OCTOBER 21-24 / ATLANTA, GA

Society of Cable Telecommunications Engineers

CCAP Case Study:

Enabling Converged Video + Data thru Space & Power Savings

A Technical Paper prepared for the Society of Cable Telecommunications Engineers
By

John Ulm
Fellow of Technical Staff
ARRIS
john.ulm@arrisi.com

Jeff Finkelstein
Executive Director of Strategic Architecture
Cox Communications
Jeff.Finkelstein@cox.com

Saifur Rahman
Distinguished Engineer
Comcast Cable
Saifur_Rahman@Cable.Comcast.com

Jorge Salinger
V.P. Access Architecture
Comcast Cable
Jorge_Salinger@Cable.Comcast.com

Abstract

The Converged Cable Access Platform (a.k.a. CCAP) era has finally arrived as operators begin to deploy CCAP products in their labs and in the field. As CCAP technology becomes validated, operators can focus on the operational aspect of CCAP, which includes converging the video and data/voice silos. Convergence has been a large hurdle to overcome and has met with much resistance. Are the benefits from CCAP enough to clear this final hurdle?

This paper documents a case study on multiple head ends looking at the impact of migrating to the CCAP architecture. A cross section of several actual Head Ends (HE) were analyzed in depth and compared to a CCAP based Head End design. The results explicitly quantify the benefits of converging video and data using CCAP. Of particular note is the space and power savings seen. Detailed rack elevations are also presented to illustrate the potential space savings. Other factors analyzed include simplified operations from collapsing RF combining, reduced Ethernet interconnections, and network management consolidation.

The case studies looked at a good cross section of today's Head Ends (HE) from moderate sized suburban HE to extremely large Urban HE. Both integrated and modular CMTS sites are considered. In addition to the space and power savings, CCAP can provide a decade's worth of growth in a smaller footprint than today's existing CMTS / EQAM equipment and RF combining.

For operators who have been hesitant to pull the trigger on Video + Data convergence, this case study provides the ammunition they need to not only justify the convergence, but accelerate it.

CCAP Introduction

Growth in narrowcast services continues to put pressure on MSOs to expand narrowcast bandwidth to customers. These services consist of traditional High Speed Data (HSD), Video on Demand (VoD), Switched Digital Video (SDV), network DVR (nDVR) services and eventually IP video services.

With this increased demand, MSOs are expanding their narrowcast footprint using a wide variety of methods to free up bandwidth such as analog reclaim, node splits and service group segmentations.

Changes like these require extensive efforts from multiple groups including engineering, operations and head end teams. Leveraging a CCAP environment would streamline much of the physical head end work done today, allowing for more efficient management of the services supplied through the box.

Current Landscape

As service offerings continue to expand and the end users' appetite for these services continues to grow, MSOs are putting tremendous effort into keeping up with the demands on the edge network. Initially, these services were focused on the expansion of High-Definition TV (HDTV) content. In many cases this was addressed through reducing or removing analog channels, enhanced encoding techniques and through the use of Switched Digital Video (SDV) to allow more content to be delivered to subscribers. At the same time, narrowcast service demands also increased. Much of this demand stems from growing Video on Demand (VoD) usage, increasing High Speed Data (HSD) usage from customers with multiple end devices in the home and new narrowcast services like nDVR.

To address the need for additional narrowcast spectrum, operators continue to reduce service group size and expand the number of QAMs within each service group. The continued demand for QAMs has resulted in equipment suppliers creating more densely populated designs allowing for the scalability of QAMs per port and QAMs per chassis.

This current trend does not seem to show signs of subsiding anytime soon. The concern is the finite resources, including space, power and cooling, used to handle these expansions within the head end and/or hub.

Expanding the narrowcast spectrum has been very costly for operators in terms of resource and time. CCAP devices will allow operators the flexibility to cable once and grow narrowcast services incrementally. This advantage is done in a couple of ways. First, the platform will have the ability to support the entire RF spectrum on a single RF port. This also allows the QAMs to transmit any type of service supporting DOCSIS, VoD and linear QAMs on the same port while reducing the need to modify combining architectures. Non-contiguous QAM support also cuts down on the need for frequency realignments in the markets. With the ability for all the services to be fed out of a single platform, one of the biggest challenges will be the management of those services within a single platform.

CCAP in a Nutshell

Many people are already familiar with CCAP. For those who are not, here are some important CCAP facts:

- CCAP stands for Converged Cable Access Platform
- Combines the functions of a CMTS and dense edge QAM into a single platform
- Eventually implements all narrowcast and broadcast QAMs in a single RF port
- Offers many operational features for scaling an all-digital network

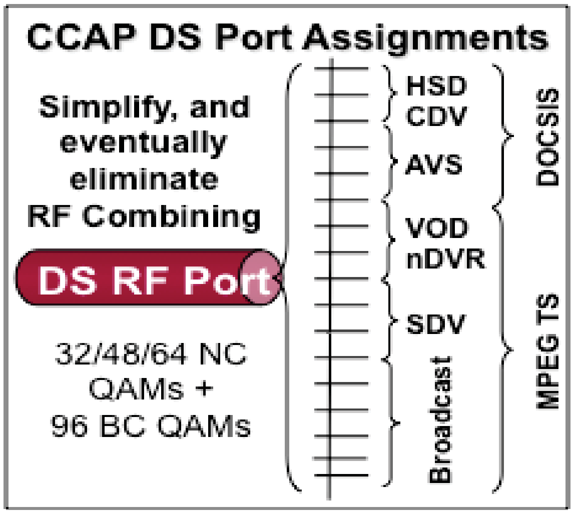

Figure 1: CCAP Port Configuration

Figure 1 shows how a single port of a CCAP includes all the QAMs for a given service group, including MPEG-TS for broadcast and narrowcast video services, and for DOCSIS applications.

CCAP was designed specifically to support growth in the number of QAM channels used for narrowcast services, such as VoD and SDV, the expansion of HDTV content, and the availability of channel bonding in DOCSIS® 3.0 to support higher bandwidth data services.

As MSOs continue to reduce the size of service groups to make more efficient use of their networks and deploy advanced services such as IP-based video and network DVR, even more QAM modulators are needed. CCAP devices will provide the necessary QAM-per-RF-port and port-per-chassis density needed to support this growth while requiring less space and power than currently available equipment. This results in a reduction of capital and operational costs along with simplified operations.

Why do MSOs need CCAP?

There are many reasons for CCAP success amongst MSOs even before the equipment has become available. The key reasons are listed in table 1.

Key Drivers for CCAP	
Engineering	Significant space savings with simultaneous increase in capacity
	Significant power savings plus less cooling
	Improve existing UPS and battery backup performance
Network Architecture	Minimum, simplified combining wiring
	Full-spectrum, MPEG/DOCSIS QAMs, easier migration to ADS
	Future proof, single access platform
Purchasing	Much lower CapEx cost, especially for downstream!!
	Lower OpEx costs, including power and cooling
Operations	Fully redundant (N+1 for line cards and 1+1 for common equipment)
	Configuration change between QAM types vs. equipment swap-out
	Much shorter maintenance window (ISSU)
	Far less equipment to manage and maintain

Table 1: Key Drivers for CCAP

While these are important points for CCAP, supporting the growth of narrowcast QAMs is the primary goal of the new platform. Figure 2 depicts an example for the growth of narrowcast services. As can be seen by the figure, there is not only a change in the mix of broadcast and narrowcast services, but the relative mix of MPEG and DOCSIS channels within the narrowcast services is changing over time as well.

In addition to narrowcast channels increase over time, there will be a continued reduction in the size of Service Groups (SG). This means that each head end will need to support more and more SG over time. This will put a significant space and power burden on operators. Figure 3 below gives a preliminary guess at the space savings an operator might experience. The purpose of this paper is to provide a quantified measure of the space and power savings that operators can attain from CCAP.

CCAP Migration Strategies

Two basic DOCSIS systems are prevalent in operators head ends today: Integrated CMTS (I-CMTS) and Modular CMTS (M-CMTS). For both systems, there are multiple variations on how they might migrate to a final CCAP state. Figure 4 shows an I-CMTS migration where the CCAP initially replaces the I-CMTS and then later integrated the video EQAM into the CCAP system.

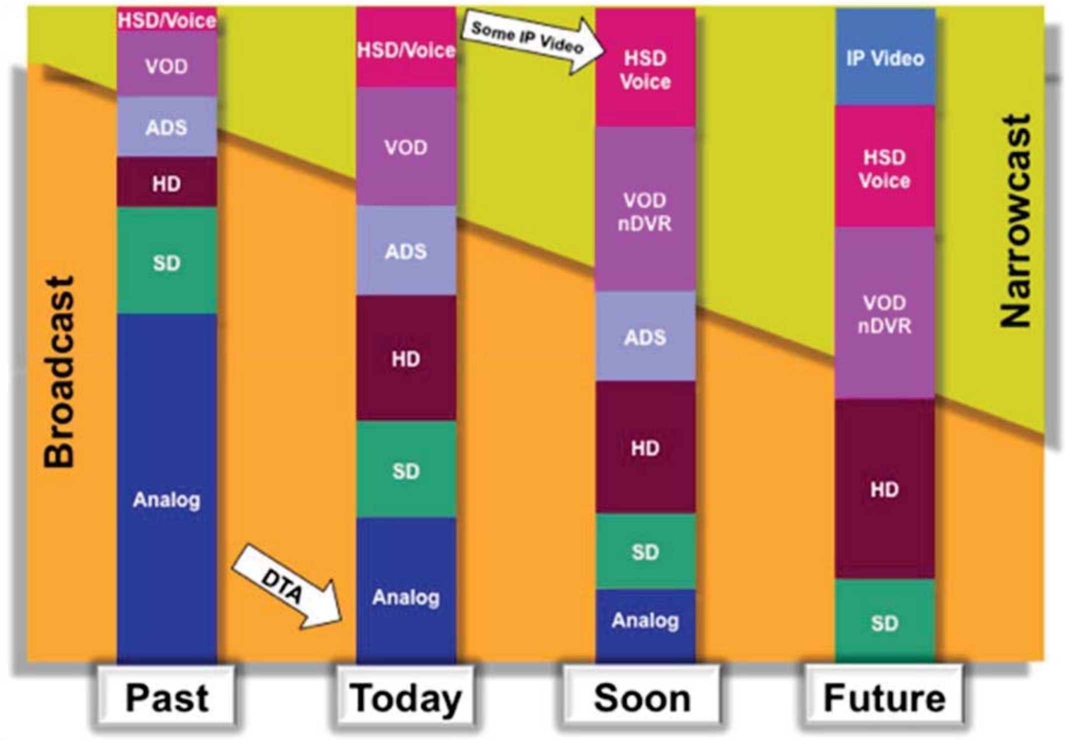

Figure 2 – Allocation of Spectrum per Service type over Time

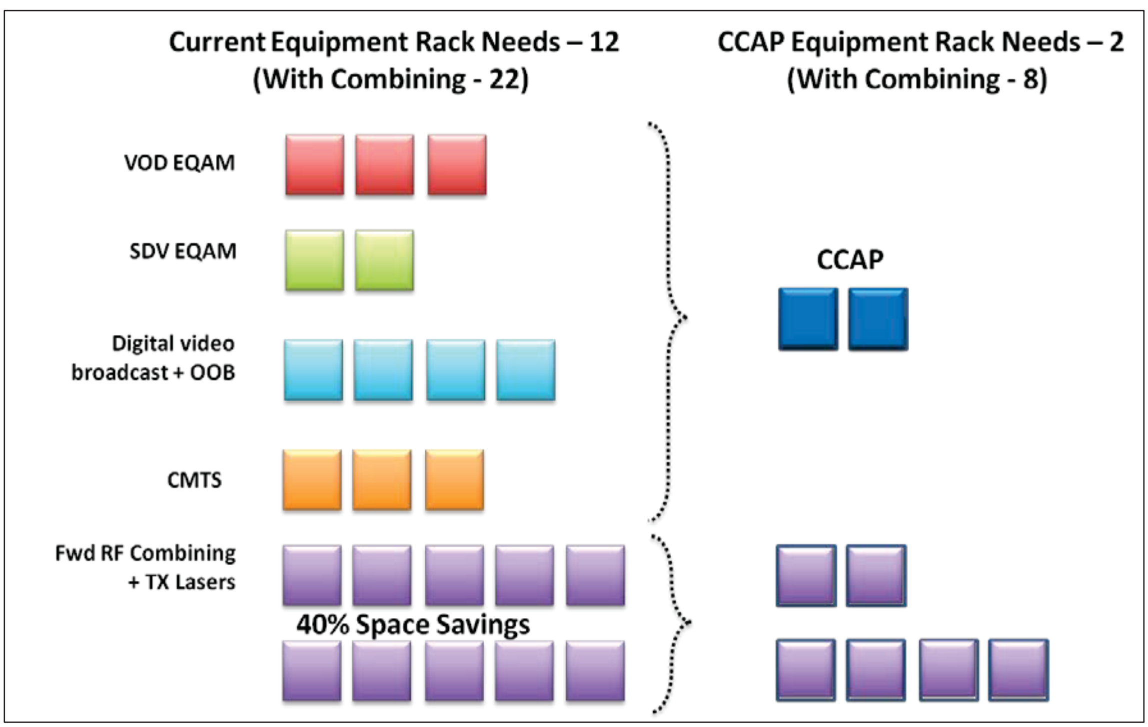

Figure 3 – Preliminary CCAP Space Savings Example

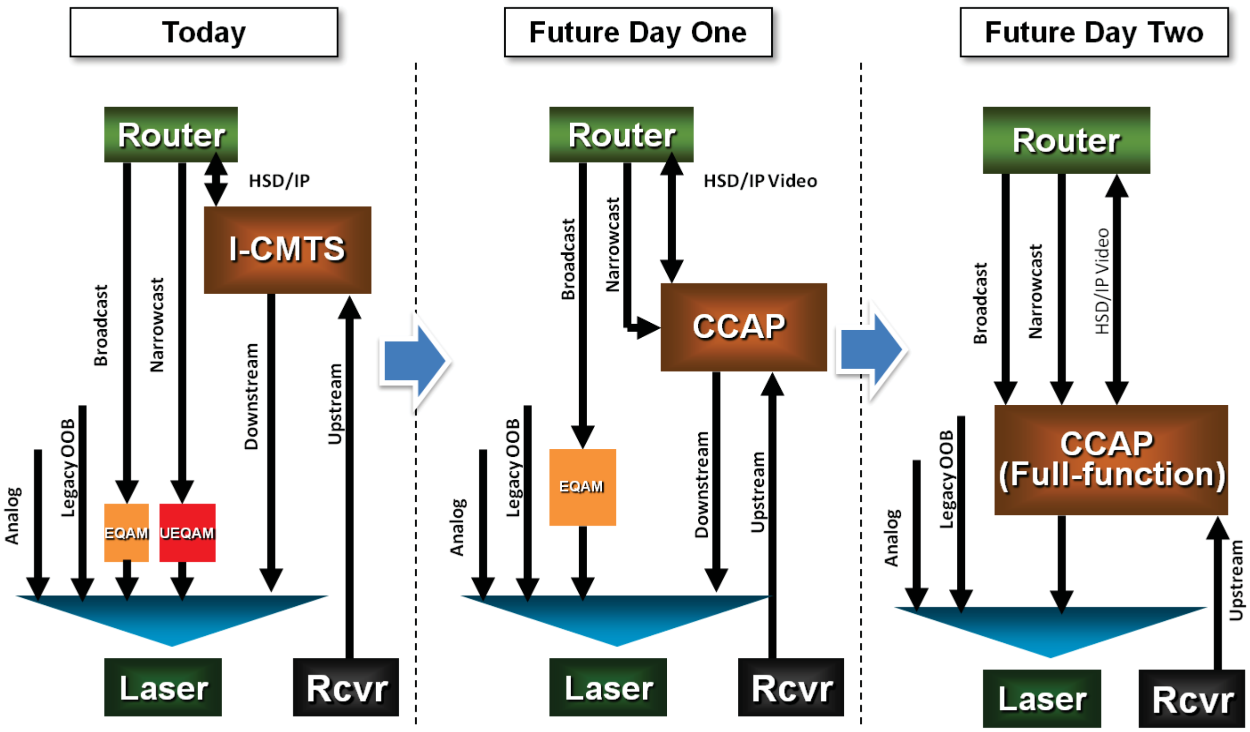

Figure 4 – CCAP Migration Scenario: I-CMTS Example

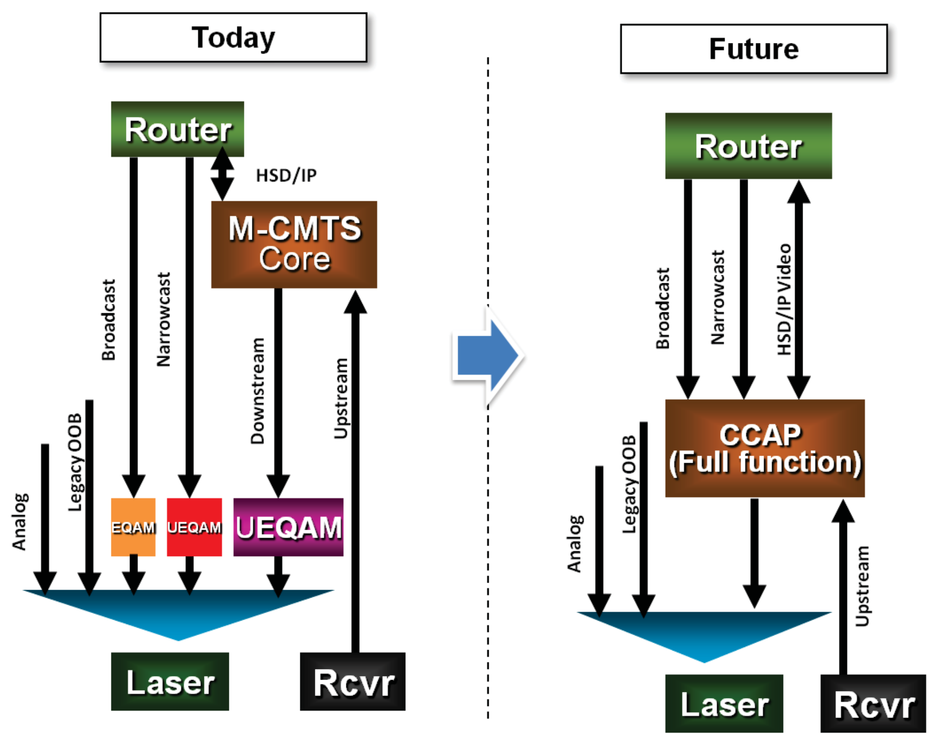

Figure 5 – CCAP Migration Scenario: M-CMTS Example

Figure 5 shows the M-CMTS to CCAP migration that is done in a single step. This could also have been broken into multiple steps. Note – if a high density EQAM is deployed as an initial step towards CCAP, this can collapse video and DOCSIS channels onto a single RF port to provide many of the CCAP benefits. This paper is focused on the final CCAP state and does not detail any intermediate steps.

CCAP Case Study Site Overview

For our case study, it was important that we understand the impacts of CCAP across a variety of head end sizes and architectures. The case study includes a couple of moderate sized suburban hubs in addition to a pair of very large urban master head ends. For each, one was an I-CMTS system and the other was a M-CMTS system. In addition to these, we selected another Urban Hub site that was “bursting at the seams”.

The breakdown for each head end is shown in Table 2 Below.

Site Sizing	Urban #1 Master HE	Urban #2 Hub	Suburban Hub #1	Suburban Hub #2	Urban #3 Master HE
VOD Service Groups	672	304	90	72	179
SDV Service Groups	-	-	-	-	226
HSD Downstream SG	672	304	92	73	432
HSD Upstream SG	672	304	153	87	432
Optical Nodes	**723**	**368**	**177**	**94**	**452**
CCAP DS SG	**672**	**304**	**104**	**94**	**448**
CCAP Upstream SG	**672**	**304**	**168**	**94**	**448**

Table 2 Case Study – Service Group Sizes

As can be seen from the data, Urban #1 is the largest of the head ends with a total of 723 nodes and 672 Service Groups (SG). Note that the number of video and HSD SG are identical. This site has already forced SG alignment between services. It has also almost reached one SG per node. This means that further SG splits are going to require node splits as well. The crowded Urban #2 Hub had 304 SG in 368 nodes. It has also achieved video and HSD SG alignment. Both Urban #1 and Urban #2 were I-CMTS sites.

The Urban site #3 was our large M-CMTS site with a total of 452 nodes. This location also had SDV services thrown into the mix as well. While Urban #3 had achieved almost

1:1 ratio of HSD SG with nodes, the VOD and SDV SG count were still significantly smaller than HSD SG. For our CCAP migration, it would require 448 CCAP SG.

The two smaller suburban hubs (one I-CMTS, one M-CMTS) give us some insights into CCAP benefits for small to moderate sized head ends. These sites had not achieved SG alignment yet between video and HSD. Another unique aspect to these locations is that many of the SG had a 2:1 ratio of upstream ports to downstream ports.

Some head ends such as Urban #1 are arranged in a “Pod” architecture. This typically refers to an arrangement where all of the CMTS, Edge QAM, and associated components (power supply, narrow cast combine, etc.) are put into one rack such that it acts as a self-contained narrowcast QAM entity and connects to AM optics (TX and RX laser). This can allow a cookie cutter replication of narrowcast functions in a head end with AM optics of each serving groups that are physically separated from each other. The “Pod” is sized to serve one subdivision of homes with one CMTS and a few EQAMs units. For most existing CMTS implementations this yields about a service group size of 24 to 36. CCAPs are designed to service a much wider area and usually can encompass more than 2x this size. The size difference results in mismatch between the “Pod” architecture and CCAPs.

There are two basic approaches to dealing with the size mismatch of the “Pod” architecture. The easiest way is to preserve the existing service group size of the “Pod” and to deploy the CCAP initially without a full complement of line cards. Even in this configuration the CCAP will provide benefits in terms of cost and power per QAM channel. This benefit grows over time as user capacity demands would generally force the “Pod” architecture to be reconfigured to support multiple CMTS and/or EQAM chassis due to the limited capacity of today’s CMTS and EQAMs. CCAPs by comparison offer a much large capacity and a single chassis should support services for at least 10 years. An alternative approach is to re-configure or remove the “Pod” partitions such that one CCAP serves multiple of the areas of the original “Pod”. This could be accomplished by consolidating the “Pods” that are in close physical proximity of the connected AM optics. There is also another option that could be available in a future CCAP; line card with an embedded AM optics. This could allow one CCAP to serve all of the different areas connected to all of the “Pods”.

CCAP Chassis Savings

The existing head ends and hub sites used a variety of EQAM technology, with some of it being rather dated compared to today’s high density universal EQAM products. This meant that several HE had multiple EQAM ports per SG, which in turns means more EQAM devices are required. Table 3 below shows the total number of EQAM and CMTS chassis required today for each head end.

The table also shows how many CCAP chassis are required to replace all of the EQAM and CMTS devices. For this paper, we used a CCAP density of 56 SG per chassis for 1:1 US:DS ratios and 48 SG per chassis for 2:1 US:DS ratios. This is based on commercially available CCAP products that are in the field today.

Chassis Counts	Urban #1 Master HE	Urban #2 Hub	Suburban Hub #1	Suburban Hub #2	Urban #3 Master HE
Video EQAM	81	31	5	4	160
M-CMTS EQAM	-	-	-	5	6
CMTS	31	15	5	2	6
Total Chassis	**112**	**46**	**10**	**11**	**172**
CCAP Chassis	**12**	**6**	**2**	**2**	**8**
Chassis Savings	**89%**	**87%**	**80%**	**82%**	**95%**

Table 3 – Chassis Count

As can be seen in Table 3, there is a significant reduction in the number of unique chassis in the system. This benefit is seen across all types of head ends and ranges from 80% to 95% reduction in the total number of devices in the head end.

CCAP Space Savings

With SG sizes constantly being slashed, the number of SG that a head end must support will continue to skyrocket. This will put a severe strain on most if not all head ends over time. Space savings is one of the key benefits of CCAP.

CCAP Equipment Space Savings

The potential equipment space savings for our case study is shown in Table 4 below.

For most of the head ends in our case study, the CMTS equipment accounted for the bulk of the equipment rack space. The only exception to this was the Urban #3 site where EQAMs were more significant. Part of this is attributed to being a M-CMTS site, but the main culprit was the relatively old video EQAM technology being deployed there.

The introduction of CCAP can enable significant space savings by replacing the legacy EQAM and CMTS equipment. At the Urban #1 site, almost ten racks of equipment are freed up. At the crowded Urban #2 hub, almost two thirds of the equipment rack space is freed. For four of the five head ends in the case study, equipment space savings ranged from 60% to 68%. The only site that didn't achieve these savings was Suburban site #2 which still saw 41% space savings. It turns out that this site was already deploying relatively newer EQAM technology than the other sites. Also, it only needed two CCAP chassis and the 2nd chassis was partially filled. As this site needs more SG splits, the 2nd CCAP will be filled up without incurring additional rack space.

Space Savings		Urban #1 Master HE	Urban #2 Hub	Suburban Hub #1	Suburban Hub #2	Urban #3 Master HE
Existing Equip (RU)	Video EQAM	162 RU	62 RU	10 RU	8 RU	220 RU
	M-CMTS EQ	-	-	-	10 RU	78 RU
	CMTS	434 RU	210 RU	70 RU	36 RU	108 RU
	Total Equip	**596 RU**	**272 RU**	**80 RU**	**54 RU**	**406 RU**
CCAP Space		**192 RU**	**96 RU**	**32 RU**	**32 RU**	**128 RU**
CCAP Equip Savings		**404 RU**	**176 RU**	**48 RU**	**22 RU**	**278 RU**
% Savings		**68%**	**65%**	**60%**	**41%**	**68%**

Table 4 – CCAP Space Savings, Equipment

For this case study, we only considered the integration of narrowcast channels into the CCAP system. The broadcast channels were left external to the CCAP box and provide potential for further space savings in the future.

CCAP RF Combining Space Savings

There is more to the CCAP space savings story than just the savings from reduced equipment chassis. There is also a significant savings from the simplified RF Combining that comes with a “Wire Once” strategy.

For our case study, a head end design team performed a detailed analysis for collapsing the RF combining with CCAP. Figure 6a shows the existing RF combining design for one of the suburban hubs. Figure 6b shows the updated design with CCAP. Notice that this is still a fairly conservative design as a four way combiner was left in the CCAP path to allow for test monitoring with two spare inputs. This means that our case study numbers could be improved even further if needed.

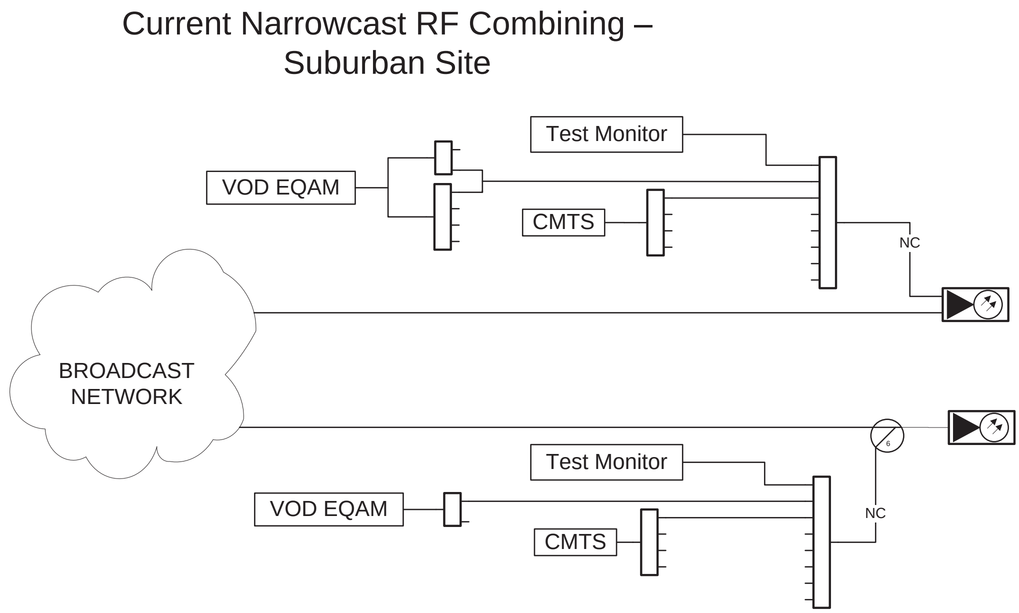

Figure 6a – RF Combining Example: Existing

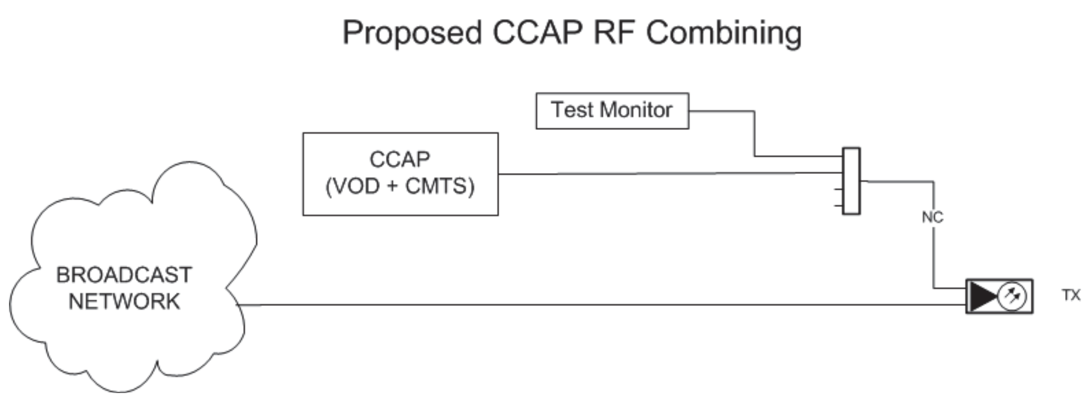

Figure 6b – RF Combining Example: After CCAP Migration

The net space savings from this RF combining simplification is shown in Table 5 below along with the equipment space savings discussed previously. Note that the Urban site #3 had the most savings from RF combining. As mentioned earlier, this site was using older EQAM technology than the other head ends and this resulted in a correspondingly larger RF combining network. The RF combining space savings was more than 6 racks for this location.

The other Urban sites, #1 & #2, both had almost three racks of space freed from the RF combining simplification. The Suburban sites were proportionately smaller savings with a rack of space freed up.

Space Savings – RF Combining	Urban #1 Master HE	Urban #2 Hub	Suburban Hub #1	Suburban Hub #2	Urban #3 Master HE
RF Combining Savings (narrowcast only)	**120 RU**	**128 RU**	**40 RU**	**40 RU**	**250 RU**
CCAP Equip Savings	404 RU	176 RU	64 RU	38 RU	278 RU
Combined RU Savings	**524 RU**	**304 RU**	**104 RU**	**78 RU**	**528 RU**

Table 5 – CCAP Space Savings, RF Combining

Table 5 also shows the combined rack savings from the reduction in equipment plus the RF combining simplification. Interestingly, Urban #1 saw most of its space gains from equipment reduction while the other head ends saw a more equal savings from equipment and RF combining. So in general, the RF combining savings is an equally important point to the CCAP migration. The total space savings seen at both master head ends, Urban #1 & #3, results in a dozen racks being recovered.

One of the most important aspects of space savings is that it frees up space to allow for the expansion of Service Groups as the SG size is continually reduced. Table 6 takes a look at how many additional SG could be supported by CCAP with the space that has been freed up.

Space Savings – RF Combining	Urban #1 Master HE	Urban #2 Hub	Suburban Hub #1	Suburban Hub #2	Urban #3 Master HE
Combined RU Savings	**524 RU**	**304 RU**	**104 RU**	**78 RU**	**528 RU**
CCAP SG: Replacement	672	304	104	94	448
CCAP SG: Expansion using All Space Savings	2464	1400	448	392	2296
CCAP Space Multiplier	**3.7X**	**4.6X**	**4.3X**	**4.2X**	**5.1X**

Table 6 – CCAP Space Savings, RF Combining

The bottom row of Table 6 shows the “multiplier” factor for how many additional SG can be supported with the additional space savings. Using Urban site #1 as an example, it supports 672 SG today. By filling the freed space from equipment and RF combining savings with additional CCAP boxes, a total of 2464 SG could be supported at this site. This is a 3.7X increase in SG growth. The other head ends show an even larger SG multiplier with Urban #3 coming in at a 5.1X increase in SGs.

A rough rule of thumb is that migrating to CCAP can free enough space to quadruple the SG count within the existing footprint.

Also note that the above space savings was only factoring narrowcast integration into the CCAP system. Integrating the broadcast would increase the space savings even further.

CCAP Power Savings

The next critical aspect of CCAP migration is the impact on head end power. As SG counts continue to rise, power may be the next limiting factor after space. The case study did a detailed analysis of the current CMTS + EQAM power requirements and then compared that to the CCAP power requirements. This is detailed in Table 7 below.

Power Savings		**Urban #1 Master HE**	**Urban #2 Hub**	**Suburban Hub #1**	**Suburban Hub #2**	**Urban #3 Master HE**
Existing Equip (KW)	EQAM	40.6	15.6	2.8	4.9	48.8
	CMTS	82.5	39.9	9.0	3.6	10.8
	Total	**123 KW**	**55.5**	**11.8**	**8.5**	**59.6**
Power per DS+US (W)		**11.4 W**	**11.3**	**8.0**	**7.3**	**8.6**
CCAP Total Power (KW)		**45.0 KW**	**20.9**	**7.0**	**5.9**	**29.2**
CCAP Pwr per DS+US (W)		**1.1 W**	**1.1**	**1.1**	**1.0**	**1.0**
Net PwrSavings (KW)		**78.1**	**34.6**	**4.8**	**2.6**	**30.4**
% Savings		**63%**	**62%**	**41%**	**31%**	**51%**

Table 7 – CCAP Power Savings

First let's take a look at the Total power usage. For Urban site #1, the existing CMTS + EQAM consume 123KW of power. With the migration to CCAP, this drops to 45KW for a 63% savings in power. Urban site #2 had a similar savings of 62%. The two Suburban sites that were using relatively newer EQAM technology saw power savings in the 30% to 40% range. Again, one of the two CCAP chassis were partially filled which helped account for the diminished power savings. Urban site #3 came in middle of the road with a ~50% power savings.

Another interesting aspect to consider is the power per channel. For CMTS and CCAP systems, this must include the Upstream (US) channels in addition to the Downstream (DS) channels. Table 7 shows the all inclusive average power per DS SG. As can be seen, the CCAP is anywhere from 7X to 10X better in power per channel. CCAP can expand from 16 to 32 to 64 narrowcast channels without any appreciable increase in overall system power. Legacy CMTS and EQAM equipment might require a doubling or even quadrupling of system power to support that narrowcast increase.

CCAP Operational Savings

One of the key aspects to CCAP is the operational savings that it will introduce. These savings are manifest in several different ways. This includes ease of management to the ability to quickly do node splits.

Fewer Chassis to Manage

Previously in Table 3, it was shown that the number of physical chassis in the head end is reduced anywhere from 80% to 95%. The net effect of this is that there is a dramatic simplification in managing boxes in the head end.

In the two large Master head ends, the number of chassis are reduced from more than 100 down to only 8 to 12 chassis. The two Suburban sites see everything collapse down to only two CCAP chassis.

Simplified RF + Ethernet Interconnections

The next important aspect of CCAP is the ability to easily and quickly perform SG splits as needed. Today it is a labor intensive task, especially where the video and HSD SG are not aligned.

In order to quantify the benefit, Table 8 shows the amount of RF Interconnect and the savings from CCAP.

RF Interconnections	Urban #1 Master HE	Urban #2 Hub	Suburban Hub #1	Suburban Hub #2	Urban #3 Master HE
Total RF Interconnects: Existing EQAM	1458 ports	558 ports	4956 connects	2632 connects	1348 connects
Total RF Interconnects: CCAP	675 ports	306 ports	2832 connects	1504 connects	448 connects
RF Interconnect Savings	**783 ports 54%**	**252 ports 45%**	**43%**	**43%**	**67%**

Table 8 – RF Combining + Ethernet Interconnect Savings

For Urban site #3 with the most complex RF combining, there was a savings of 67% in the number of narrowcast RF interconnects. For Urban sites #1 & #2, the number of RF ports was reduced by ~50%. The Suburban sites with newer, denser EQAM saw a 43% reduction in the number of RF interconnects. All of this RF combining simplification along with the CCAP QAM replication ability to enable video/HSD SG alignment leads to a significantly simplified path to SG splits.

Another aspect to head end operations is managing the north bound Ethernet interface connections from the CMTS and EQAM to the operator's metro routers. Almost all existing EQAM and CMTS are using 1G Ethernet connections. With the move to CCAP, there will be a migration to 10G Ethernet interfaces. So, not only will there be fewer chassis to interconnect, but these will be done with fewer high capacity 10G Ethernet links. Table 9 provides a summary of the Ethernet connections.

Ethernet Connections	Urban #1 Master HE	Urban #2 Hub	Suburban Hub #1	Suburban Hub #2	Urban #3 Master HE
Total E-net Connections: Existing EQAM (1G)	273	108	30	54	301
Total E-net Connections: CCAP (10G)	50	22	8	8	32
Ethernet Port Savings	**223 ports 82%**	**86 ports 80%**	**22 ports 73%**	**46 ports 85%**	**269 ports 89%**

Table 9 – RF Combining + Ethernet Interconnect Savings

As can be seen by the table, there is a 73% to 89% reduction in the number of Ethernet ports required of the Metro router. Not only will there be operational savings from the reduced Ethernet connections, but the operators may see CAPEX savings from reduced port requirements on their metro routers.

CCAP Case Study Conclusion

The inception of CCAP has held out the promise of many benefits, including:

- Frees Rack Space
- Reduces Head End power
- Less Network + RF Interconnections
- Fewer Boxes to Manage

Until now, these benefits have been hard to accurately quantify. This case study has looked at a range of head ends: from moderate to massive, from integrated to modular.

Most of the head ends saw more than 60% reduction in equipment rack space. Many of these space savings were then matched with space savings from simplified RF combining. The net effect of this saved space is that operators can now roughly quadruple their SG count within their existing footprint. This is equivalent to two node splits.

The power savings are also dramatic with the larger head ends savings 50% to 63% of their CMTS + EQAM power. In addition to total power, the power per DS channel is also reduced by a factor of ten while supporting four times the narrowcast capacity.

The "Wire Once" strategy provides significant rack savings from simplified RF combining and makes SG splits to be operationally simpler. The case study shows that RF interconnections are reduced by about 50%. The study shows even larger gains in the Ethernet port with reductions on the order of 80%. All of this leads to simpler operations and maintenance of the head end.

In addition to quadrupling the SG count, 1st generation CCAP devices will also quadruple the narrowcast channel capacity for every SG. This means that CCAP can enable a 16-fold increase in narrowcast capacity within existing head end footprints. Once the future migration to DOCSIS 3.1 occurs, another two to four fold increase in port capacity is possible. This means that CCAP enables head end growth well into the next decade.

For operators who have been hesitant to pull the trigger on Video + Data convergence, this case study provides the ammunition they need to not only justify the convergence, but accelerate it.

References

1. "*Deploying CCAP: Just Another Box, or an Operational Sea of Changes*", J. Salinger, T. Pearman, SCTE Cable-Tec Expo, Orlando, Oct 2012
2. "*Understanding and Planning CMAP Network Design and Operations*", J. Salinger, SCTE Cable-Tec Expo, Oct 2010
3. "*CMAP Objectives and Energy Savings*", J. Salinger, Light Reading Green Broadband Conference, Sep 2010
4. "*CCAP: More than just Box, replacement*", J. Salinger, T. Pearman, CED, May 2012

Appendix – Example RF Combining Simplification

Figure A1 below shows the existing RF Combining circuitry at one of the Urban head end sites. Figure A2 shows the proposed RF Combining design after the CCAP migration.

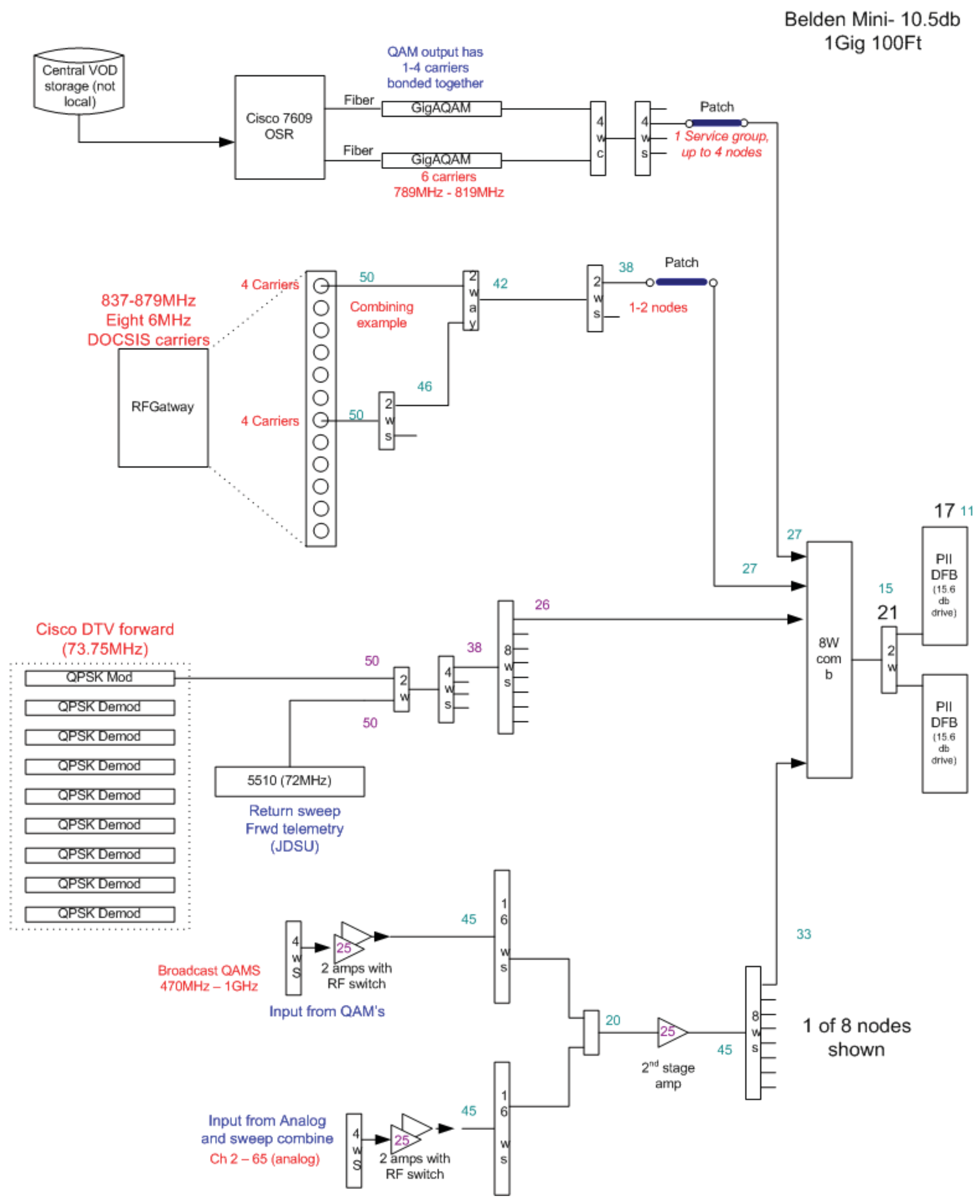

Figure A1 – RF Combining Example #2: Existing

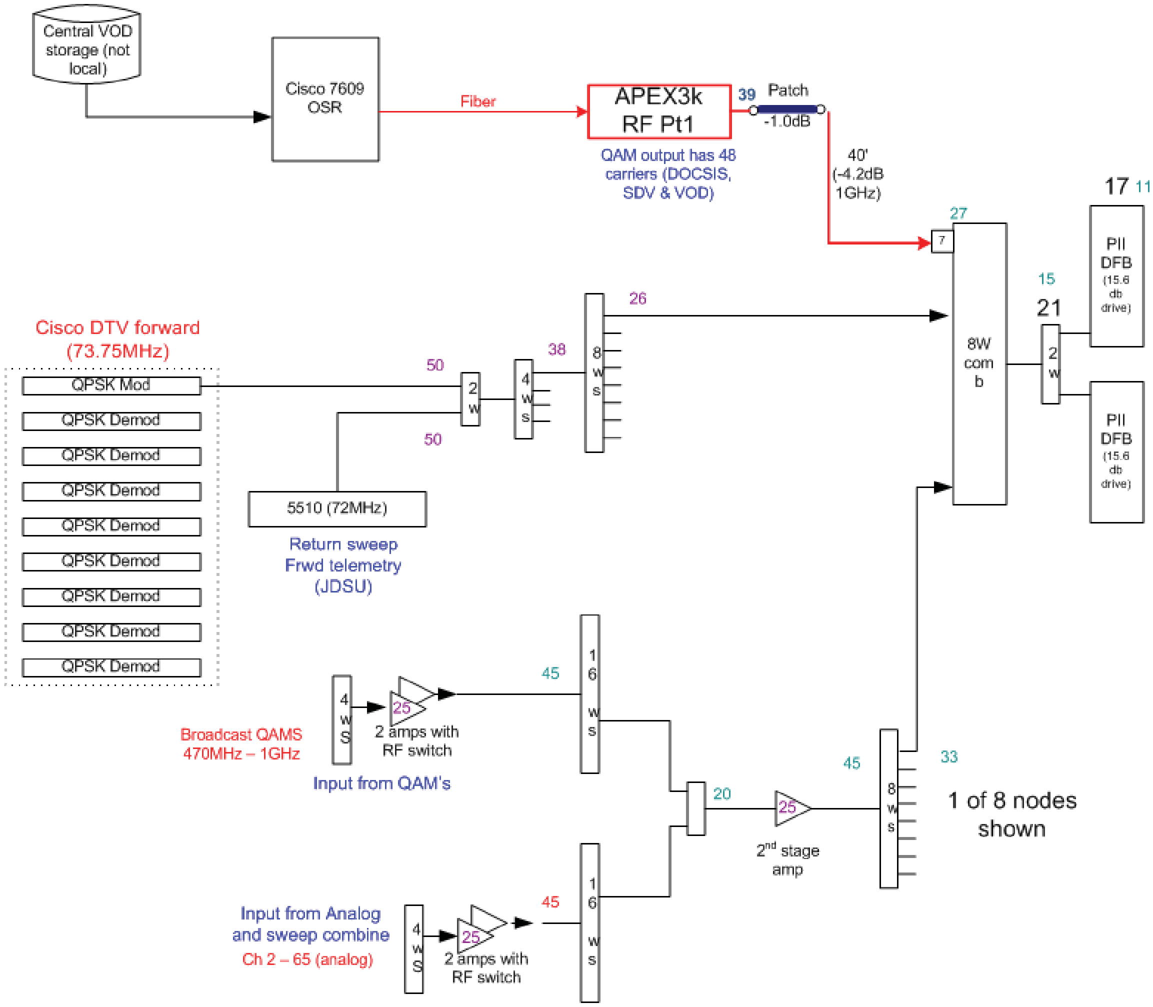

Figure A2 – RF Combining Example #2: After CCAP Migration

Appendix – Example Rack Elevations

The following are example rack elevations that first show the existing head ends and then the CCAP rack elevation.

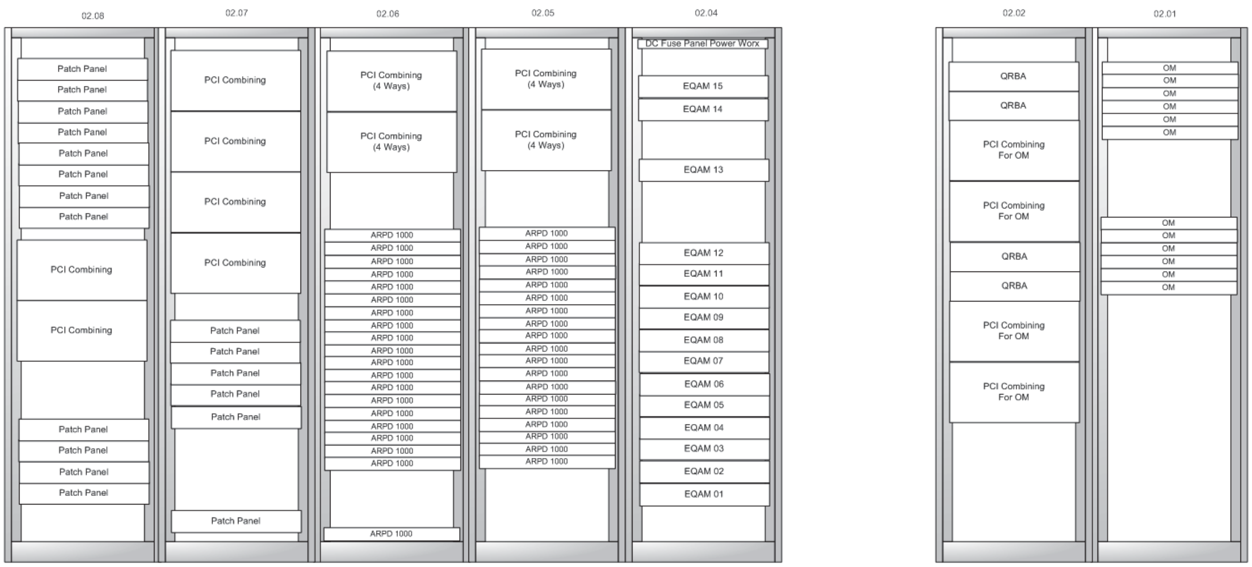

Figure A3 – Urban Hub EQAM & RF Combining Rack Elevation – Existing

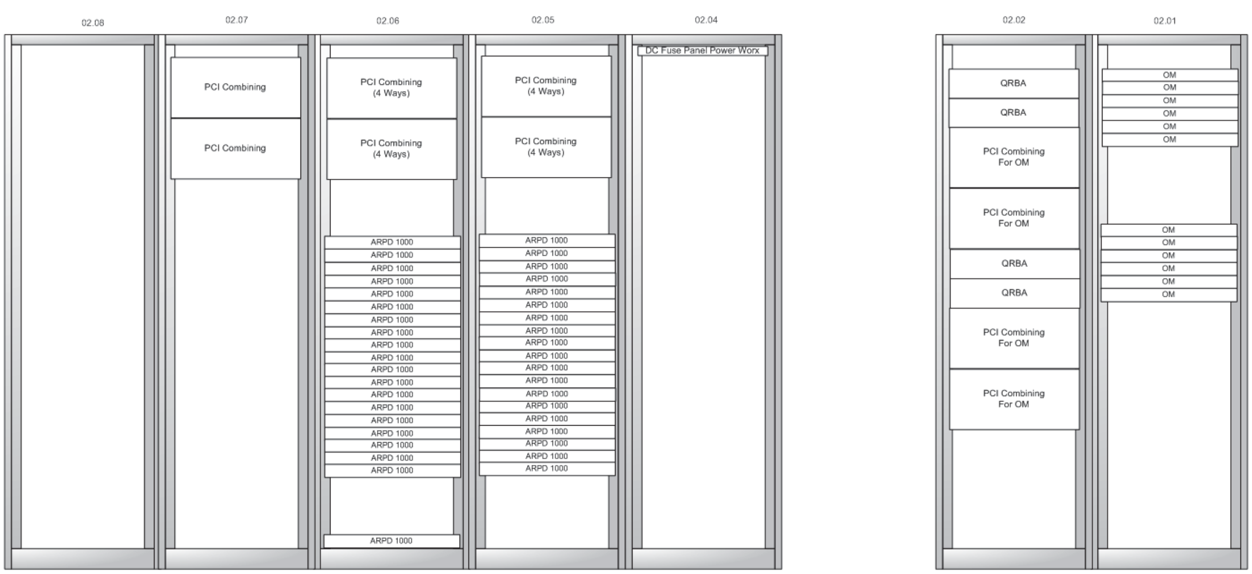

Figure A4 – Urban Hub EQAM & RF Combining Rack Elevation – After CCAP

Figure A5 – Urban Hub CMTS Rack Elevations – Existing

Figure A6 – Urban Hub CMTS Rack Elevations – After CCAP Migration

Figure A7 – Suburban Rack Elevation Example – Existing

Figure A8 – Suburban Rack Elevation – After CCAP Migration

Abbreviations and Acronyms

ADS	All Digital Simulcast
BC	Broadcast
CCAP	Converged Cable Access Platform
CMTS	Cable modem termination system
DOCSIS	Data over cable service interface specification
DVR	Digital Video Recorder
HDTV	High Definition Television
HE	Headend
HSD	High-speed Data
HSI	High-speed Internet
IP	Internet Protocol
MPEG	Moving Picture Experts Group
MSO	Multiple system operator
nDVR	Network Digital Video Recorder
NC	Narrowcast
OTN	Optical termination node
ORT	Operational Readiness Trial
QAM	Quadrature amplitude modulation
RF	Radio frequency
SCTE	Society of Cable and Telecommunications Engineers
SDV	Switched digital video
SNMP	Simple network management protocol
TS	Transport Stream
VoD	Video on-demand