Cambium Networks™

# Meeting CAF (Connect America Fund) Phase II Performance Tiers with Cambium Networks PMP Solutions

## CONNECT AMERICA FUND

CAF (Connect America Fund) was established by the Federal Communications Commission of the United States to provide funds to facilitate service providers in connecting rural America with high speed internet. CAF Phase I occurred earlier in the decade. CAF Phase II is in progress now.

CAF Phase II allowed service providers to bid to provide high speed internet to specific block groups of rural America with different performance tiers. These tiers include:

- Gigabit; >= 1000/500 Mbps
- Above Baseline; >= 100/20 Mbps
- Baseline; >= 25/3 Mbps
- Minimum; >= 10/1 Mbps

The service provider chose the performance tier they were prepared to meet for 95% of the locations in a block group. Winning an auction for a specific block group commits the provider to meeting the performance designated in the bid. 40% of locations in a block group must be complete by year 3, 60% by year 4, 80% by year 5, and 100% by year 6.

The service provider can select any technical solution to meet the performance tier, such as fiber, satellite, or best in class Fixed Wireless Broadband products from Cambium Networks. This paper explores how both current and future cutting edge PMP technology from Cambium Networks can be used to successfully execute the bids from CAF Phase II award winners for Above Baseline, Baseline, and Minimum performance tiers.

## CAF BUILDING BLOCK 1: THROUGHPUT TO MEET CAF PERFORMANCE TIERS

Cambium Networks presently has several PMP solutions to meet the specified Above Baseline, Baseline, and Minimum performance tiers. Under development are additions to the PMP portfolio that will soon provide CAF Phase II award winners – and any service provider in general desiring to meet these high throughput performance tiers – with the capability to handle a greater variety of PMP use cases.

### CURRENT PMP SOLUTIONS THAT MEET "BASELINE, 25 / 3 MBPS" AND "ABOVE BASELINE, 100 / 20 MBPS" PLANS

**450 Product Family**

Cambium's flagship PMP 450 family of products already meets 100/20 Mbps throughput plans with 20, 30, and 40 MHz channels. If only 25/3 Mbps throughput is required, 10 and 15 MHz channels can also be utilized. GPS synchronization and frequency reuse allow for efficient channel planning to support a large customer base on a small number of channels.

**ePMP 2000 / ePMP 1000**

The ePMP 2000/ePMP 1000 product line provides an industry-leading, high performance PMP solution at one of the most attractive price points in market. 100 / 20 Mbps throughput plans can be achieved using 40 MHz channels. If only 25/3 Mbps throughput is required, 10 and 20 MHz channels can be utilized, too. GPS synchronization and frequency reuse allow these products to provide efficient channel planning to support a large customer base on a small number of channels.

### FUTURE PMP SOLUTIONS THAT MEET "BASELINE, 25 / 3 MBPS" AND "ABOVE BASELINE, 100 / 20 MBPS" PLANS

**ePMP 3000 and Force 300 AP**

The next generation ePMP 3000 is an 802.11ac standards base chipset solution providing increased throughput and PPS performance while maintaining one of the most accessible price points for PMP solutions. 100/20 Mbps throughput plans will be achieved on 20, 40, and 80 MHz channels.

The Force 300 AP will soon be available, with a similar ability to support 100/20 Mbps throughput plans on 20, 40, and 80 MHz channels. The Force 300 AP is affordably priced and can be connected to narrow beamwidth antennas such as horn antennas to efficiently cover SMs over a small azimuth.

It is the plan of intent that ePMP 3000 and Force 300 AP products are intended for release in Q4 2018, allowing plenty of time to meet initial CAF Phase II requirements to deploy 40% of locations by year 3.

Customers already deployed with existing ePMP 1000 SMs continue to work with the new ePMP 3000 AP and Force 300 AP at the same throughput plans they previously experienced.

**cn Ranger ™ LTE Solutions at 2 . 5 and 3 . 6 5 GHz**

The Cambium Networks LTE solution cnRanger™ has a plan of intent to be introduced in Q1 2019. The 2.5 GHz band is due for release first, followed within the year by the 3 GHz band. The initial release will include a CAT 4 SM, with the following releases also providing for a CAT 6 SM and carrier aggregation, then finally the release of a CAT 12 SM.

CAT 4 SMs support 25/3 Mbps. CAT 6 SMs along with carrier aggregation – which are two 20 MHz channels used together for 40 MHz of total bandwidth – support 100/20 Mbps. CAT 12 SMs support 100/20 Mbps on a single 20 MHz channel without the need of carrier aggregation.

The cnRanger family of products are intended to be available by year 3 of CAF II, when the initial 40% of CAF II customers in a block group must be online and functional.

## CAF BUILDING BLOCK 2:MU-MIMO TO INCREASE THE AMOUNT OF SMS SUPPORTED PER AP

As noted in CAF Building Block 1, Cambium Networks offers three different product families to meet the CAF Phase II "Baseline, 25/3" and "Above Baseline, 100/20" performance tiers. But, the possibilities continue. To handle these high throughput performance tiers for a larger number of customers at a lower price per AP, Cambium Networks 450m and ePMP 3000 product families include industry leading MU-MIMO (Multi User MIMO) capability. MU-MIMO allows for multiple streams of data to be sent and received by an AP with multiple SMs at the same time, effectively providing an "X" boost factor.

### CURRENT MU - MIMO SOLUTIONS

**450m in 5 GHz**

450m in 5 GHz supports 14x14 Massive MU-MIMO, enabling data to be sent simultaneously to up seven SMs, offering effectively seven times the performance of a non-MU-MIMO solution. In real world experience, customers report up to four times the previous performance. This performance gain with the latest release of software is now seen in both the DL and the UL, allowing many more CAF Phase II end customers to realize CAF Phase II performance tiers from just a single AP.

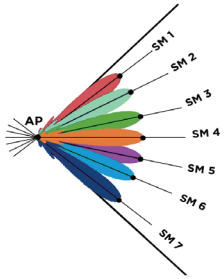


*Figure 1 – MU-MIMO to seven users simultaneously with 450m in 5GHz*

**450m in 3.65 GHz**

450m in 3.65 GHz supports 8x8 Massive MU-MIMO and is now debuting as the first product in the industry to support MU-MIMO in the 3 GHz band. Data can be sent concurrently to up four SMs, offering effectively four times theperformance of a non-MU-MIMO solution. In real world applications, customers can expect to experience two and a half to three times performance. This performance gain offers the same benefits as listed for the 450m in 5 GHz listed in the above paragraph.

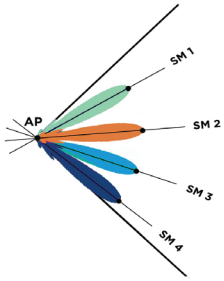


*Figure 2 – MU-MIMO to four users simultaneously with 450m in 3.6GHz*

### FUTURE MU-MIMO SOLUTIONS

**ePMP 3000 with MU-MIMO Sector Antenna**

ePMP 3000 with Cambium Networks MU-MIMO sector antenna has a plan of intent to support 4x4 MU-MIMO, with release in Q4 2018. Data can be sent in parallel to two SMs, offering effectively two times the performance of a non-MU-MIMO solution in the DL. As with the entire ePMP product family, cutting edge features are offered at market leading prices, allowing many more CAF II end customers to realize performance tiers from just a single AP.

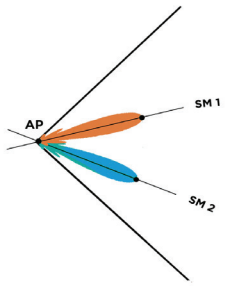


*Figure 3 – MU-MIMO to two users simultaneously with ePMP 3000*

**ePMP 3000 with Third Party Horn Antennas**

ePMP 3000 with third party horn antennas allows for 4x4 MU-MIMO to function on azimuths as low as 45 degrees,enabling the 2x performance to be focused on a cluster of SMs.

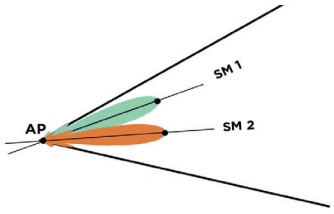


*Figure 4 – MU-MIMO to two users simultaneously in 45-degree azimuth with ePMP 3000*

## CAF BUILDING BLOCK 3: COVERING THE HARD TO REACH SMS

Cambium Networks continuously strives to improve key product performance, and this is the case with coverage area. To address this, current and future product releases are designed to support 3.65 GHz and 2.5 GHz, which not only provide better propagation than 5 GHz, but also have higher transmit power and EIRP limits – meaning greater link budgets.

The result is that coverage for CAF Phase II performance tiers extends further and also propagates better in NLOS conditions, solving the problem of coverage for those 10% of customers that are very difficult to reach in a CAF Phase II block group.

### CURRENT 3.65 GHZ SOLUTIONS

**450m in 3.65 GHz**

450m in 3.65 GHz has it all. Beyond best in class throughput due to Massive MU-MIMO, it also has incredible coverage and ability to handle NLOS subscribers. Distances of 2x which means 4x the area can be covered – as compared to competitor 5 GHz non-MU-MIMO solutions – while also providing twice as much throughput. This translates into fewer towers, less equipment, and less personnel time to maintain a CAF Phase II network – and can be run in TDD Sync with other Cambium Networks APs in 5 GHz reducing overall system interference. Those hard to reach customers are not so hard to reach anymore; just overlay a 3.65 GHz site onto the 5 GHz site.

**450i in 3.65 GHz**

In case only a few hard to reach customers need to be connected, the 450i in 3.65 GHz is available to provide a cost effective 3.65 GHz solution.

### FUTURE 3.65 AND 2 GHZ SOLUTIONS

**450b SM in 3.65 GHz**

The 450b SM is Cambium's cost-effective subscriber in 5 GHz, and is also intended for release in 1H 2019 for 3.65 GHz. This SM will lower the cost to cover those hard to reach CAF Phase II customers now accessible via a 3.65 Cambium Networks solution.

**cnRanger LTE Solutions at 2.5 and 3.65 GHz**

The Cambium Networks LTE solution, cnRanger™, will ship in both 2.5 and 3.65 GHz, providing best in class range/coverage capability. Those few hard to reach subscribers that can prevent meeting the 95% coverage for a block group are now accessible. For the especially tough to reach subscribers, cnRanger at 2.5 GHz provides not only the enhanced propagation benefits of 2.5 GHz, but also a high powered 8W per chain AP option, in addition to best in class transmit power for LTE SMs.

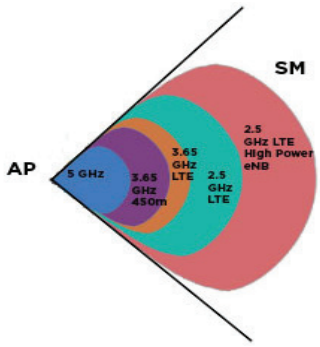


*Figure 5 – Covering Hard to Reach CAF Phase II SMs with 450m in 3.65 GHz and cnRanger (LTE)*

## CAF BUILDING BLOCK 4: COVERING THE HARD TO REACH CLUSTER OF HOMES

Have a small group of homes that have trouble being reached by a distant high-site AP due to lots of foliage?Overcome that obstacle with a Cambium Networks MicroPop solution. It is the plan of intent that within 2019, MicroPop or low-site outdoor solutions will be available in both the 450 and ePMP product families. A low-cost MicroPop AP can be placed at a fiber drop or PTP termination point mounted above a key building in a neighborhood, town, or a cluster of buildings in the country and connect up with several nearby SMs.

### FUTURE MICRO POP SOLUTIONS

**450 Micro-Pop in 5 GHz**

A 450 MicroPop solution based on the 450b platform and including GPS Sync has a plan of intent for release in 2019, providing the low-cost benefits of 450b as a cost-effective AP to cover a small, low-site area with all the benefits expected of a Cambium Networks AP.

**Force 300 AP**

Force 300 AP also will be deployable as a low-site MicroPop solution and will include GPS Sync if desired, providing high performance at an industry leading price point. Force 300 AP has a plan of intent to be available in Q1 of 2019.

## THREE PRODUCT FAMILIES TO MEET ALL CAF PHASE II PERFORMANCE REQUIREMENTS

Cambium Networks provides cutting edge technologies that meet the CAF Phase II performance tiers for all outdoor wireless use cases with the three product families; 450, ePMP, and cnRanger.

The 450 product line is Cambium's high end PMP solution, delivering:

- Industry leading throughput for sectors and sites utilizing Massive MU-MIMO technology in 5 and 3.65 GHz to cover as many customers as possible with CAF II compliant service plans
- Superior range with 3.65 GHz solutions to reach tough NLOS customers
- Ability to serve hard to reach high site customers with a low site MicroPop solution

The ePMP family of products is Cambium's high performing PMP solution at an industry leading price point, delivering:

- High capacity MU-MIMO throughput for both traditional sectors using a state-of-the-art MU-MIMO sector antenna, and narrow azimuth sectors down to 45 degrees using horn antennas
- Ability to serve hard to reach high site customers with a low-site MicroPop solution

The cnRanger family of products is Cambium's upcoming low cost, high performance LTE solution, which will deliver:

- Best in class link budget and hence range to reach the toughest NLOS CAF Phase II customers
- Support in 2.5 and 3.65 GHz
- Growing roadmap on industry standard LTE which results in ever increasing system throughput and price competitive SMs

Cambium Networks is the only company that provides the variety of PMP technologies needed to meet any CAF Phase II use case. Throughput, range, narrow beam sectors, and low-site are all solved in affordable solutions to reach all target customers.

Cambium Networks™

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