Cambium Networks™

CO-LOCATION GUIDE

PMP 450 Plaftorm and LTE

When co-locating systems in the same geographical area it is important to select the correct system parameters in order to avoid interference. Both Cambium PMP and LTE are TDD systems, which means that the same frequency resources are used both in the downlink and in the uplink, but multiplexed in time. A TDD cycle, or frame, is the minimum amount of time used to communicate in both directions, including gaps for hardware turnaround and over the air propagation delays.

When multiple access points (APs) are deployed in the same geographical area, it is important that they all transmit and receive at the same time. If one AP transmits when another receives, the AP that is receiving might not be able to correctly decode the signal coming from the subscriber modules (SMs) communicating with it, because of the interfering signal coming from the other AP.

In order to avoid this type of interference, three aspects need to be considered:

1- The TDD cycle, or frame, needs to have the same length for all APs

2- The TDD cycle, or frame, needs to start at the same time for all APs

3- The frame parameters need to be selected in each AP so that there is no overlap between one AP transmitting and another receiving. An example of these parameters is the duty cycle, i.e. the ratio of the time dedicated to communication in the downlink direction over the total time frame.

NOTE that these parameters do not need to be the same in all APs, but they need to be selected to avoid interference. These features are needed regardless of the technology used by the APs.

LTE FRAME CONFIGURATION OPTIONS

Table 1 summarizes the LTE frame configuration options.

LTE supports two frame lengths, 5 ms and 10 ms. Each 10 ms interval contains 10 subframes, which are labeled in the Table as D for downlink transmission, U for uplink transmission, and S for special subframe. The special subframe contains the turnaround time between downlink and uplink transmissions.

CONFIGURATION	FRAME TIME	SUBFRAME NUMBER									
		0	1	2	3	4	5	6	7	8	9
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

Table 1 - LTE frame configuration options

FRAME LENGTH

TDD systems can be co-located only if they have the same frame length.

Figure 1 shows why it is not possible to co-locate APs supporting mismatched frame lengths.

Let us assume that AP1 operates with a 10 ms frame while AP2 operates with a 5 ms frame. Figure 1 shows that in a 10 ms interval AP1 has one transmit time and one receive time, while AP2 has two transmit times and two receive times.

The interference that mostly affects the system performance is the one at the AP receiver. For example, in the time indicated with the green arrow in Figure 1, AP1 transmits when AP2 receives. This may completely corrupt the reception of AP2's uplink signal.

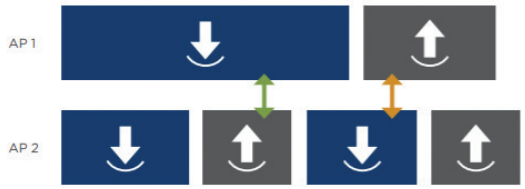

Figure 1 - Mismatched frame length

Also, in the time indicated with the orange arrow in Figure 1, AP2 transmits when AP1 receives. This may completely corrupt the reception of AP1's uplink signal.

As indicated above, LTE supports 5 ms and 10 ms frame lengths. Cambium PMP devices support 2.5 ms and 5 ms frame length. The only option for co-locating LTE and Cambium PMP devices is for both systems to operate with a 5 ms frame. This means that a Cambium PMP system can be co-located with an LTE system operating with Frame Configurations 0, 1 or 2.

Note that frame configuration 6 also turns around twice in the 10 ms interval, and its frame length is 5 ms. However, the two 5 ms frames in the 10 ms interval are not identical.

Since in the Cambium PMP system all frames have the same downlink/uplink structure, the Cambium PMP system cannot be co-located with an LTE system operating with Frame Configuration 6.

In the Cambium PMP GUI the frame length is selected in the Configuration → Radio → Radio Configuration page under Frame Period, as shown in Figure 2. This parameter must be configured to 5 ms.

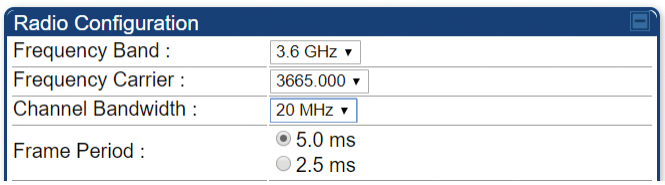

Figure 2 - Frame length selection in Cambium PMP GUI

FRAME START

GPS synchronization is a way of guaranteeing that the frame start is the same for all APs. This is what is used by the Cambium PMP devices.

However, the timing between the GPS signal and the start of the TDD frame is not necessarily the same for all systems. The Cambium PMP devices and the LTE devices have different start time for their frames.

The Cambium PMP Radio configuration page offers an LTE co-location option in the GUI Radio page, that allows the user to co-locate Cambium PMP devices with LTE devices by shifting the start of the PMP frame to match the start of the LTE frame.

This can be found under Configuration → Radio → Frame Configuration, as shown in Figure 3.

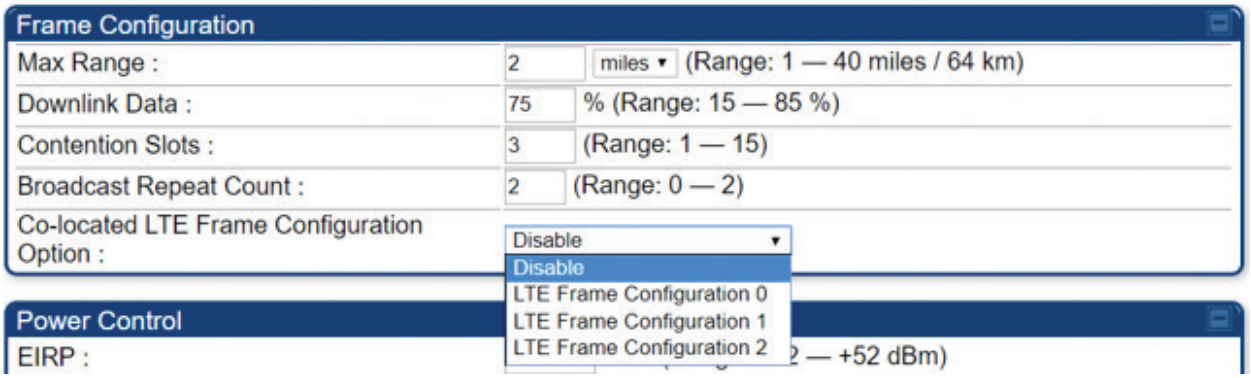

Figure 3 - Options for co-location with LTE systems

If the Co-located LTE Frame Configuration Option is selected as Disable, then the Cambium PMP frame start is not shifted from its legacy timing.

If any of the three other options (LTE Frame Configuration 0, 1 or 2) is selected, the Cambium PMP frame start is shifted to align to the LTE frame start. Additionally, each Frame Configuration has its frame start shifted by an integer number of subframes.

The Cambium PMP frame always starts with the downlink portion of the frame, followed by the turnaround time and then the uplink portion of the frame.

The LTE 10-ms interval however, always starts with subframes D, S and U as the first three subframes, but it may have additional downlink subframes in the same frame.

For example, in Frame Configuration 1 the 10 ms interval is composed of two repetitions of the following subframes: D, S, U, U, D. In order to align the Cambium PMP frame to this LTE frame, the downlink start has to align to the beginning of subframe 4, not subframe 0. With this shift, the sequence of subframes in the LTE frame becomes D, D, S, U, U, which is the same structure of the Cambium PMP frame (downlink, turnaround time, uplink).

When selecting one of the LTE Frame Configuration options from the Co-located LTE Frame Configuration Option drop-down menu, a shift is applied to the Cambium PMP frame in order to correctly line up with the selected LTE frame.

FRAME PARAMETERS

After following the steps described above, the Cambium PMP and the LTE APs are synchronized, and their frame length is the same.

Next, the frame parameters have to be selected in order to avoid any overlap between one AP transmitting and another receiving.

Figures 4 and 5 show one example of frames that do not interfere and one example of frames that do interfere. In both Figures the downlink time and the uplink time of the two APs are not identical.

In Figure 4 there is no overlap between one AP transmitting and another AP receiving, and the two APs can be co-located.

In Figure 5 however, AP1 is still transmitting when AP2 is already receiving. This creates interference at the AP2's receiver and the APs cannot be co-located with these parameters.

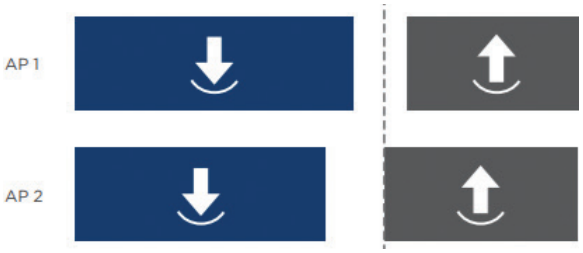

Figure 4 - Example of APs that can be co-located

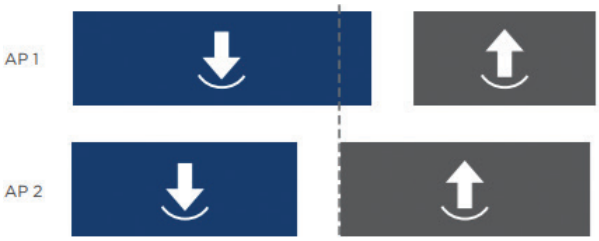

Figure 5 - Example of APs that cannot be co-located

Once the LTE Frame Configuration is selected from the drop-down menu, the LTE downlink and uplink times are defined.

The Cambium PMP frame times are determined by the following configuration parameters:

- Channel Bandwidth: amount of spectrum allocated for communication in the sector

  Options for the Channel Bandwidth in the 3 GHz band are 5 MHz, 7 MHz, 10 MHz, 15 MHz, 20 MHz, 30 MHz and 40 MHz.

- Max Range: distance between the AP and the farthest SM communicating with the AP

  Max Range is selected in miles, between 1 and 40.

- Downlink Data: duty cycle, ratio between the time dedicated to downlink transmission and the total frame time

  Downlink Data is selected as a percentage, between 15% and 85%.

- Contention Slots: time symbols reserved in the uplink portion of the frame for random access, registration and bandwidth request

  Contention Slots is a number between 1 and 15.

The Channel Bandwidth can be configured under Configuration → Radio → Radio Configuration, as shown in Figure 6.

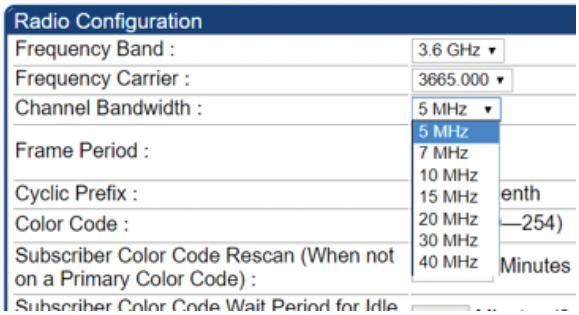

Figure 6 - Cambium PMP Channel Bandwidth configuration

All other parameters can be configured under Configuration → Radio → Frame Configuration, as shown in Figure 7.

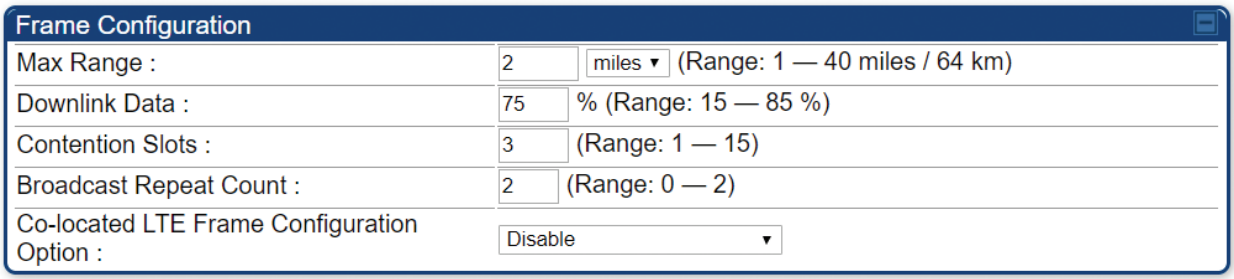

Figure 7 - Cambium PMP frame configuration parameters

PMP – LTE CO-LOCATION TOOL

The configuration parameters that affect the frame structure need to be selected in order to avoid any overlap between transmit and receive times.

In order to help with the selection of system parameters, Cambium Networks offers a PMP – LTE co-location tool, available at https://support.cambiumnetworks.com/files/colocationtool/

The PMP and LTE configuration parameters are entered in the spreadsheet, and the frame structure for the two systems is displayed on the right side.

The tool checks that there is no overlap between one AP transmitting and the other receiving.

This translates into two equations:

- The downlink time of AP1 ends before the uplink time of AP2 starts
- The downlink time of AP2 ends before the uplink time of AP1 starts

In the example in Figure 8 the second equation is not satisfied, and the two systems cannot be co-located. The plot to the right also shows that with this frame configuration the LTE AP is still transmitting when the PMP AP is already receiving. This creates interference at the PMP AP receiver.

PMP - LTE co-location tool

PMP Configuration	
Mode	PMP
Channel Bandwidth (MHz)	20
Max Range (mi)	5
Dowlink Data	70%
Contention slots	3
Frame Period (ms)	5

LTE Configuration	
Frame Configuration	2
S frame configuration	7
DL Cyclic Prefix	Normal
UL Cyclic Prefix	Normal

PMP Timing (ms)	
DL end	3.271
UL start	3.457

LTE Timing (ms)	
DL end	3.715
UL start	3.857

CHECKS					
PMP DL end	3.271	<	LTE UL start	3.857	OK
LTE DL end	3.715	<	PMP UL start	3.457	OK

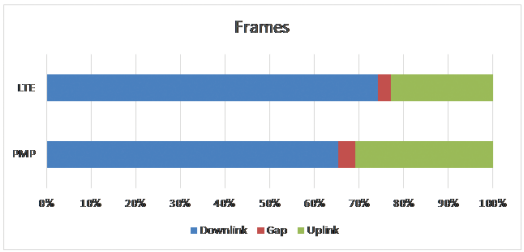

Figure 8 - Example of PMP - LTE co-location with invalid parameters

Using the tool, parameters can be updated in order to find a set of values that allows for co-location.

For example, changing the duty cycle of the PMP AP from 70% to 80% makes both equations true, and there is no longer overlap between one AP transmitting and the other receiving.

PMP - LTE co-location tool

PMP Configuration	
Mode	PMP
Channel Bandwidth (MHz)	20
Max Range (mi)	5
Dowlink Data	80%
Contention slots	3
Frame Period (ms)	5

LTE Configuration	
Frame Configuration	2
S frame configuration	7
DL Cyclic Prefix	Normal
UL Cyclic Prefix	Normal

PMP Timing (ms)	
DL end	3.708
UL start	3.894

LTE Timing (ms)	
DL end	3.715
UL start	3.857

CHECKS					
PMP DL end	3.708	<	LTE UL start	3.857	OK
LTE DL end	3.715	<	PMP UL start	3.894	OK

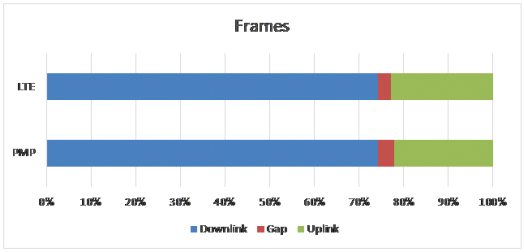

Figure 9 - Example of PMP - LTE with valid parameters

Following these steps will allow Cambium Networks 450 platform systems to be co-located with LTE-protocol systems. As indicated in another Cambium solution paper, Comparing 450 and LTE in 3 GHz (which compares system performance of the two technologies), Service Providers often find a great fit for the 450 platform when additional solutions are needed to strengthen their network and add new customers.

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