

PMP 320 to PMP 450 Migration



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INTRODUCTION

This white paper provides information to guide the user in strategies for migrating from a PMP320 deployment to a PMP450 deployment in the 3 GHz band. The objective is to be able to provide a strategy for migrating one sector at a time, versus taking a knife switch replacement approach.

This paper first addresses co-location issues when the frame sizes of the two deployments do not match. This is followed by a description of the steps to take to ensure proper co-location of the systems using the 5 ms frame feature in the PMP450 product. Specifically, proper configuration for synchronization and proper selection of the channels center frequencies are addressed.

CO-LOCATION ISSUES WITH FRAME SIZE MISMATCH

DIFFERENT FRAME SIZES

The PMP320 product series uses a frame size of 5 ms. The PMP450 product series up to release R13.2 uses a frame size of 2.5 ms. Release R13.3 of PMP450 introduces the option of a 5 ms frame size as well, which will remove most of the co-location issues of a PMP320 deployment and a PMP450 deployment.

Figure 1 shows the Tx/Rx times overlap when the frame sizes of two co-located radios do not match.

Figure 1 - Mismatch between PMP 320 and PMP 450 frame sizes

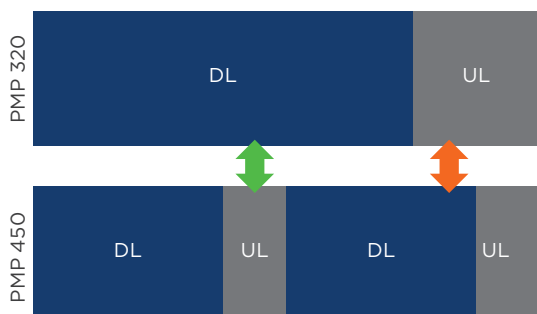


Figure 1 shows that in a 5 ms interval the PMP320 radio has one transmit time and one receive time, while the PMP450 radio has two transmit times and two receive times.

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 the PMP320 AP transmits when the PMP450 receives. This may completely corrupt the reception of the PMP450 SMs' uplink signals at the PMP450 AP receiver. Also, in the time indicated with the orange arrow in Figure 1 the PMP450 AP transmits when the PMP320 AP receives. This may completely corrupt the reception of the PMP320 SMs' uplink signals at the PMP320 AP receiver.

Additional interference is experienced at the SM site. In the time indicated with the green arrow in Figure 1 the PMP320 SM receives when the PMP450 SM transmits. Similarly, in the time indicated with the orange arrow in Figure 1 the PMP450 SM receives when the PMP320 SM transmits. This source of interference is generally less critical in the overall system performance because the SMs antennas have a narrower beam and point at the corresponding AP. Therefore the signal received by other SMs is significantly more attenuated compared to the interfering signal received at the AP.

SOLUTION

Because of the interference issue between systems with mismatched frame sizes, when PMP450 needs to be co-located with PMP320 devices, the 5 ms frame option needs to be selected.

CO-LOCATION WITH MATCHING FRAME SIZE

Release R13.3 of the PM450 product series introduces the option of a 5 ms frame size. By using this feature, interference issues presented in the previous section are eliminated because the two systems are now synchronized.

Even when using this feature, care has to be taken in configuring the PMP450 radios and in selecting the center frequencies of the PMP450 channels.

CORRECT CONFIGURATION FOR SYNCHRONIZATION

The introduction of the 5 ms feature allows the PMP320 and the PMP450 systems to be synchronized. However, the PMP450 radios have to be properly configured in order to avoid any overlap of transmit and receive times during the Tx/Rx switch.

When co-locating two PMP450 APs it is sufficient to select the same parameters (duty cycle, max range, number of contention slots, bandwidth) in order to guarantee synchronization between the two frame structures, because the Tx and Rx times are calculated by the same algorithm. However, when co-locating radios with different technologies the selection of the same parameters does not guarantee perfect synchronization, because each technology uses a different frame structure.

PMP320 supports three options for duty cycle: 75/25, 65/35 and 55/45. When selecting a 75% duty cycle in PMP450, the end of the PMP450 downlink will not exactly match the end of the PMP320 downlink, because of the different system parameters (FFT size, CP length, number of overhead symbols, number of contention slots in PMP450, frame calculator algorithm). It is therefore necessary to verify that there is no overlap in the Tx and Rx times of the two APs.

PMP450 TRANSMIT END AND RECEIVE START TIMES: FRAME CALCULATOR

The frame calculator is a tool available for the PMP450 system. It calculates the length of the transmit and receive times, together with the number of downlink and uplink symbols, for a given set of configuration parameters. The PMP450 Transmit End and Receive Start times can be found using the OFDM Frame Calculator by following these steps:

1. Obtain all configuration settings for the PMP450 AP (Downlink Data, Contention Slots, Max Range, Channel Bandwidth, Frame Length)
2. Input these configuration parameters into the OFDM Frame Calculator tool found under "Tools".

Figure 2 - OFDM frame calculator

OFDM Frame Calculator Parameters	
Link Mode :	<input type="radio"/> Point-To-Point Link <input checked="" type="radio"/> Multipoint Link
Platform Type AP/BHM :	PMP/PTP 450
Platform Type SM/BHS :	PMP/PTP 450
Channel Bandwidth :	10.0 MHz
Cyclic Prefix :	One Sixteenth
Frame Period :	<input checked="" type="radio"/> 5.0 ms <input type="radio"/> 2.5 ms
Max Range :	10 Miles (Range: 1 - 40 miles)
Downlink Data :	75 %
Contention Slots :	3 (Range: 0 — 15)
SM/BHS One Way Air Delay :	0 ns
<input type="button" value="Calculate"/>	

3. Click "Calculate"
4. Note the following values from the results:
 AP Antenna Transmit End = _____
 AP Antenna Receive Start = _____
 These values will be named PMP450 Transmit End and PMP450 Receive Start respectively.

Calculated Frame Results	
Modulation:OFDM	
Total Frame Bits : 50000	
AP Details :	
Data Slots (Down/Up) : 64 /21	
Contention Slots: 3	
Air Delay for Max Range: 54000 ns, 540 bits	
Approximate distance for Max Range: 10.053 miles (53082 feet)	
AP Antenna Transmit End : 33704, 3.370446 ms	
AP Antenna Receive Start : 35422, 3.542225 ms	
AP Receive End : 49792	
SM Details :	
SM Receive End : 34267	
SM Transmit Start : 0	
SM One Way Air Delay : 0 ns	
SM Approximate distance : 0.000 miles (0 feet)	

PMP320 TRANSMIT END AND RECEIVE START TIMES

The PMP320 system supports a limited number of configurations for duty cycle and range. The Transmit End and Receive Start times for each configuration can be found using Table 1.

The unit for the times in Table 1 is 1/10 of μ s. The reason why this unit is used is for simplicity of comparing PMP450 results, because this is the unit used for the PMP450 Frame Calculator outputs.

*Table 1 - Transmit End and Receive Start Times
for all PMP320 configurations*

BW	Duty cycle	Standard Range		Extended Range	
		Transmit End	Receive Start	Transmit End	Receive Start
3.5 MHz 7 MHz	75/25	33360	36080	30360	36080
	65/35	30270	31850	27690	31850
	55/45	24800	27520	21800	27520
5 MHz 10 MHz	75/25	36140	36740	32080	36740
	65/35	29910	30630	25970	30630
	55/45	25800	26630	23860	26630

Note that the values in Table 1 also include some margin.

VERIFICATION OF SYNCHRONIZATION

After the Transmit End and the Receive Start times have been identified for both the PMP450 and the PMP320 systems, it is necessary to verify that there is no overlap between the transmit and the receive times of the two systems.

Both the following equations have to be valid:

$$\text{PMP450 Transmit End} < \text{PMP320 Receive Start}$$

$$\text{PMP320 Transmit End} < \text{PMP450 Receive Start}$$

If both equations are satisfied, then the two systems can be successfully co-located.

If one of these equations is not satisfied, then the PMP450 duty cycle has to be adjusted (increased or decreased) until the Tx/Rx time overlap is eliminated.

EXAMPLE

Let us assume that the currently deployed PMP320 system has the following configuration parameters:

- BW = 10 MHz
- Duty cycle = 75/25
- Range = standard

Based on these parameters, the Transmit End and Receive Start times from Table 1 are:

PMP320 Transmit End = 36140

PMP320 Receive Start = 36740

A PMP450 system is deployed near the currently deployed PMP320 system. The PMP450 has the following configuration parameters:

- BW = 10 MHz
- Downlink Data = 75%
- Max range = 10 miles
- Contention Slots = 3

Using the OFDM Frame Calculator, the Transmit End and the Receive Start times are:

PMP450 Transmit End = 33704

PMP450 Receive Start = 35422

Let us now check if the co-location equations are correct:

PMP450 Transmit End < PMP320 Receive Start → 33704 < 36740 OK

PMP320 Transmit End < PMP450 Receive Start → 36140 < 35422 NOT OK

Only one of the two co-location equations is satisfied, because a 75% duty cycle in the two products translates to a different frame structure.

Let us now change the PMP450 duty cycle to 77%. The PMP450 Transmit End and Receive Start times now are:

PMP450 Transmit End = 34675

PMP450 Receive Start = 36393

Let us now check the co-location equations again:

PMP450 Transmit End < PMP320 Receive Start → 34675 < 36740 OK

PMP320 Transmit End < PMP450 Receive Start → 36140 < 36393 OK

Now both co-location equations are satisfied and the two systems can be successfully co-located.

CO-LOCATION TOOL

A PMP320-PMP450 co-location tool is available for helping with the selection of parameters during the co-location process.

This tool can be found at: <https://support.cambiumnetworks.com/files/pmp450/>

Figures 3 and 4 show the co-location tool for the example discussed above.

Figure 3 - Co-location tool with incorrect parameter selection



PMP 450		PMP 320			
PMP 450 Inputs		PMP 320 Inputs			
Channel Bandwidth	10	Channel Bandwidth	10		
Max Range (mi)	10	Dowlink Data	75%		
Dowlink Data	75%	Extended Range	No		
Contention Slots	3				
PMP 450 Timing					
DL End	33704	PMP 320 Timing			
DL Start	35422	DL End	36140		
		DL Start	36740		
CHECKS					
PMP 450 DL End	33704	<	PMP 450 DL Start	36740	OK
PMP 320 DL End	36140	<	PMP 450 DL Start	35422	NOT OK

Figure 4 - Co-location tool with correct parameter selection

PMP 450		PMP 320			
PMP 450 Inputs		PMP 320 Inputs			
Channel Bandwidth	10	Channel Bandwidth	10		
Max Range (mi)	10	Dowlink Data	75%		
Dowlink Data	77%	Extended Range	No		
Contention Slots	3				
PMP 450 Timing					
DL End	34675	PMP 320 Timing			
DL Start	36393	DL End	36140		
		DL Start	36740		
CHECKS					
PMP 450 DL End	34675	<	PMP 450 DL Start	36740	OK
PMP 320 DL End	36140	<	PMP 450 DL Start	36393	OK

CENTER FREQUENCY SELECTION

The plan for migrating a PMP320 network to a PMP450 network needs to guide in the selection of the center frequencies of the migrated channels in order to leave the correct guard bands both between a PMP320 channel and a PMP450 channel during migration, and between two PMP450 channels after migration.

GUARD BAND REQUIREMENTS

Table 2 summarizes the guard band requirements before, during, and after migration.

Table 2 - Summary of guard band requirements

Adjacent channels	20 MHz	10 MHz	7 MHz	5 MHz	3.5 MHz
Two PMP320 channels	-	1 MHz	1 MHz	1 MHz	1 MHz
Two PMP450 channels with 25 dBm SM Tx power	5 MHz	3 MHz	2 MHz	2 MHz	2 MHz
Two PMP450 channels with 23 dBm SM Tx power	0 MHz	0 MHz	0 MHz	0 MHz	0 MHz
One PMP450 channel and one PMP320 channel	2 MHz	2 MHz	2 MHz	2 MHz	2 MHz

EXAMPLES OF MIGRATION STRATEGIES

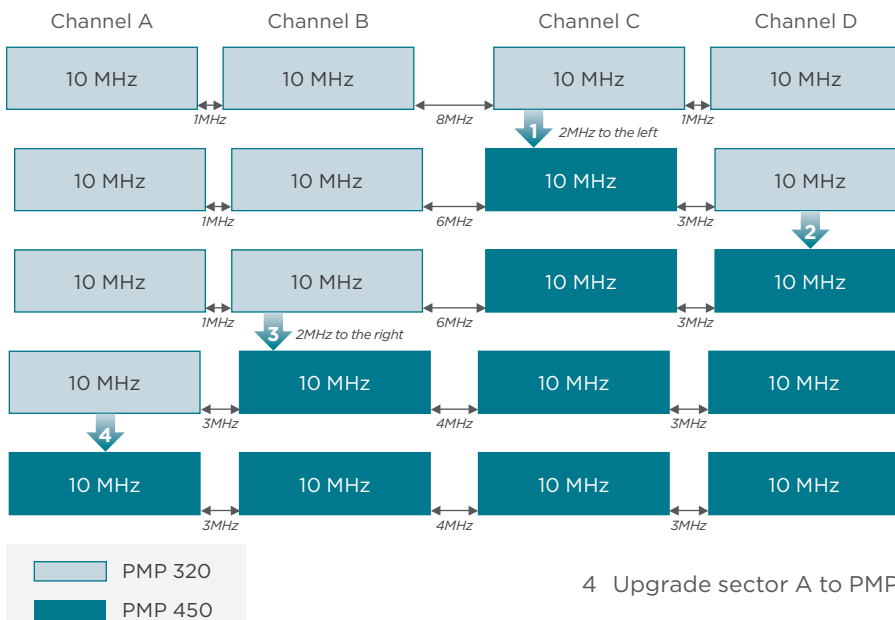
The following sections show examples for migrating a PMP320 network to a PMP450 network, with various PMP320 frequency allocations. These examples are taken from actual Cambium customers and their network deployments.

EXAMPLE 1

PMP320 WITH 4 X 10 MHz CHANNELS AND WIDER GAP IN THE MIDDLE

Figure 5 shows the migration strategy for upgrading a PMP320 network using four 10 MHz channels (A, B, C and D), with a 1 MHz gap between channels A and B, and between channels C and D, and an 8 MHz gap between channels B and C.

Figure 5 - Migration strategy for example 1



In Figure 5, the light colored channels are PMP320 channels, while the dark colored channels are PMP450 channels.

The migration of the PMP320 site to a PMP450 site can be done following these steps:

- 1 Upgrade sector C to PMP450, shifting the center frequency of channel C 2 MHz to the left.
- 2 Upgrade sector D to PMP450, keeping the same center frequency.
- 3 Upgrade sector B to PMP450, shifting the center frequency of channel B 2 MHz to the right.

- 4 Upgrade sector A to PMP450, keeping the same center frequency.

Because of the symmetry of the frequencies, an equivalent sequence of sectors to upgrade is: B, A, C and D.

The final PMP450 deployment still occupies the original 50 MHz of spectrum. The spacing between adjacent channels was 1MHz, 8 MHz, 1 MHz in the PMP320 deployment, while it is 3 MHz, 4 MHz, 3 MHz in the PMP450 deployment.

The deployment shown in Figure 5 allows PMP450 to operate with 25 dBm SM Tx power in all sectors.

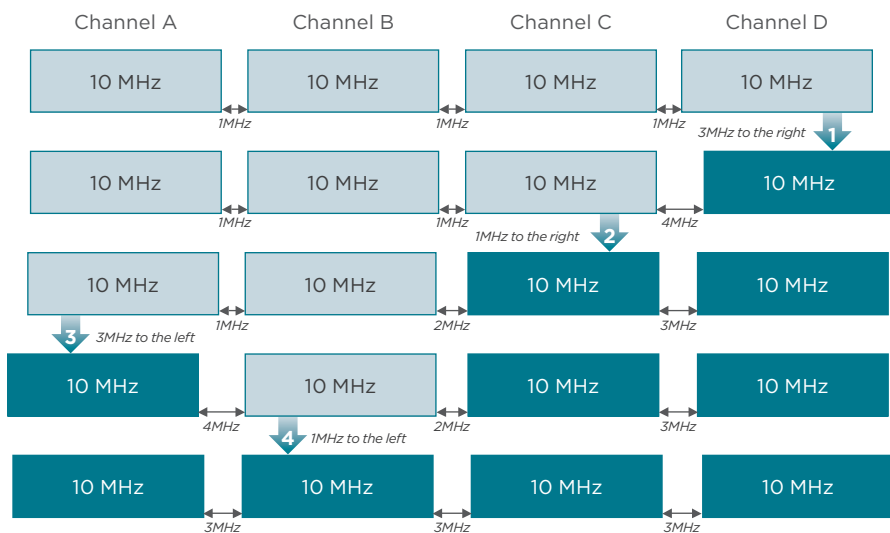
EXAMPLE 2
PMP320 WITH 4 X 10 MHz CHANNELS AND 1 MHz GAP BETWEEN CHANNELS –
PMP450 SM TX POWER AT 25 DBM

Figure 6 shows the migration strategy for upgrading a PMP320 network using four 10 MHz channels (A, B, C and D) with a 1 MHz gap between adjacent channels. This same migration strategy is valid for deployments with four 7 MHz channels.

Again, in Figure 6 the light colored channels are PMP320 channels, while the dark colored channels are PMP450 channels.

The migration of the PMP320 site to a PMP450 site can be done following these steps:

Figure 6 – Migration strategy for Example 2



- 1 Upgrade sector D to PMP450, shifting the center frequency of channel D 3 MHz to the right.
- 2 Upgrade sector C to PMP450, shifting the center frequency of channel C 1 MHz to the right.
- 3 Upgrade sector A to PMP450, shifting the center frequency of channel A 3 MHz to the left.
- 4 Upgrade sector B to PMP450, shifting the center frequency of channel B 1 MHz to the left.

Because of the symmetry of the frequencies, examples of equivalent sequences of sectors to upgrade are: A, B, D, C, or A, D, B, C.

The original PMP320 deployment used a total of 43 MHz of spectrum, while the PMP450 deployment after migration uses 49 MHz of spectrum. This solution allows PMP450 to operate with 25 dBm Tx power in all sectors.

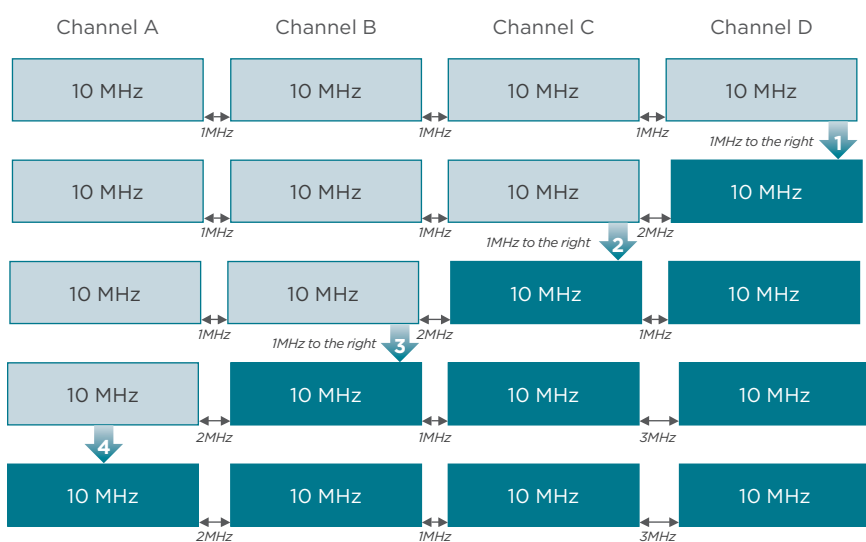
EXAMPLE 3
PMP320 WITH 4 X 10 MHZ CHANNELS AND 1 MHZ GAP BETWEEN CHANNELS –
PMP450 SM TX POWER AT 23 DBM

In Example 2, the spectrum usage after the PMP320 deployment has been upgraded to PMP450 goes from 43 MHz to 49 MHz. If spectrum usage is a concern, it is possible to limit the PMP450 SM Tx power to 23 dBm, because this solution does not require guard bands between adjacent PMP450 channels.

Figure 7 shows the migration strategy in this case. This same migration strategy is valid for deployments with four 7 MHz channels.

The migration of the PMP320 site to a PMP450 site can be done following these steps:

Figure 7 - Migration strategy for Example 3



- 1 Upgrade sector D to PMP450, shifting the center frequency of channel D 1 MHz to the right.
- 2 Upgrade sector C to PMP450, shifting the center frequency of channel C 1 MHz to the right.
- 3 Upgrade sector B to PMP450, shifting the center frequency of channel B 1 MHz to the right.
- 4 Upgrade sector A to PMP450, keeping the same center frequency.

Because of the symmetry of the frequencies, an equivalent sequence of sectors to upgrade is A, B, C and D.

The original PMP320 deployment used a total of 43 MHz of spectrum, while the PMP450 deployment after migration uses 44 MHz of spectrum.

If the center frequency of channel A is shifted 1 MHz to the right, the total spectrum usage is again 43 MHz, but shifted 1 MHz to the right compared to the original PMP320 deployment. In this case the guard bands between adjacent PMP450 channels are all 1 MHz.

If the center frequency of channel D is shifted 1 MHz to the left, the total spectrum usage is again 43 MHz, matching the spectrum usage of the original PMP320 deployment. In this case the guard bands between adjacent PMP450 channels are: 2 MHz, 1 MHz, and 0 MHz.

Legend:

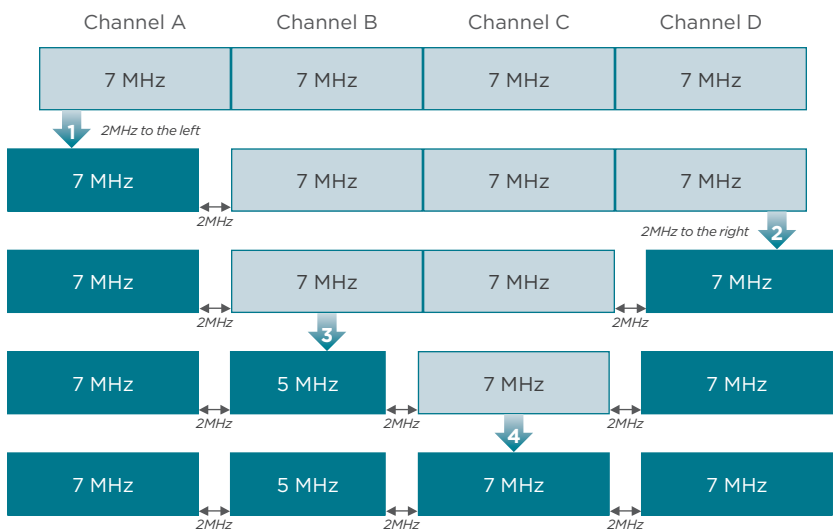
- PMP 320
- PMP 450

EXAMPLE 4
PMP320 WITH 4 X 7 MHZ CHANNELS AND NO GAPS BETWEEN CHANNELS –
PMP450 SM TX POWER AT 25 DBM

Figure 8 shows the migration strategy for upgrading a PMP320 network using four 7 MHz channels (A, B, C and D) with no gaps between adjacent channels in the case the final PMP450 deployment allows SM Tx power up to its maximum value (25 dBm).

The migration of the PMP320 site to a PMP450 site can be done following these steps:

Figure 8 - Migration strategy for Example 4



- 1 Upgrade sector A to PMP450, shifting the center frequency of channel A 2 MHz to the left.
- 2 Upgrade sector D to PMP450, shifting the center frequency of channel D 2 MHz to the right.
- 3 Upgrade sector B to PMP450, shifting the center frequency of channel B 1 MHz to the left and changing the bandwidth of channel B from 7 MHz to 5 MHz.
- 4 Upgrade sector C to PMP450, keeping the same center frequency.

Because of the symmetry of the frequencies, an equivalent sequence of sectors to upgrade is D, A, C and B.

The original PMP320 deployment used a total of 28 MHz of spectrum, while the PMP450 deployment after migration uses 32 MHz of spectrum. This solution allows PMP450 to operate with 25 dBm Tx power in all sectors.

One of the four channels has now a bandwidth of 5 MHz, compared to the original 7 MHz. In order not to lose sector capacity, it is possible to overlay another 5 MHz (or wider) channel. The total spectrum in this case would then be at least 37 MHz.

Legend:

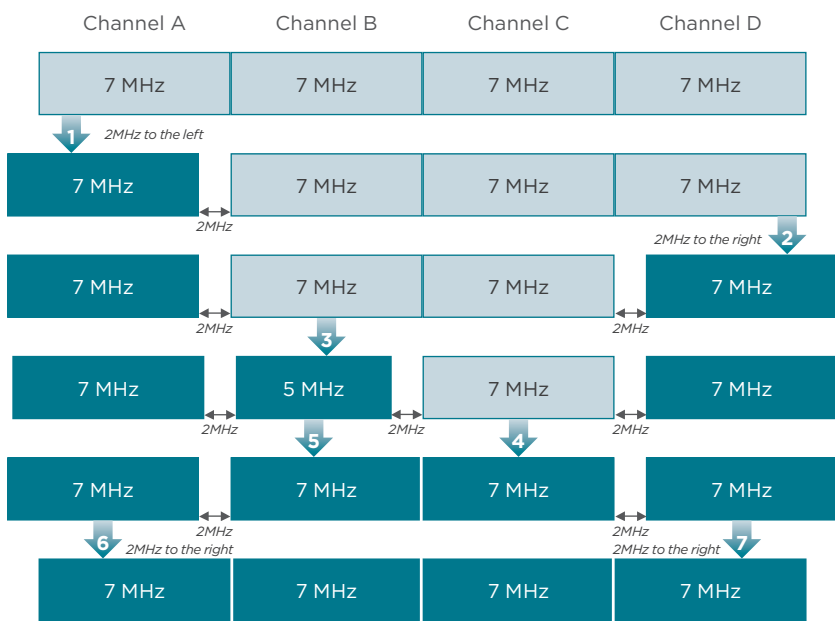
- PMP 320
- PMP 450

EXAMPLE 5
PMP320 WITH 4 X 7 MHz CHANNELS AND NO GAPS BETWEEN CHANNELS –
PMP450 SM TX POWER AT 23 DBM

Figure 9 shows the migration strategy for upgrading a PMP320 network using four 7 MHz channels (A, B, C and D) with no gaps between adjacent channels in the case the final PMP450 deployment can use adjacent frequencies in adjacent sectors (SM Tx power limited to 23 dBm).

The migration of the PMP320 site to a PMP450 site can be done following these steps (note that steps 1 to 4 are the same as in Example 4):

Figure 9 - Migration strategy for Example 5



- 1 Upgrade sector A to PMP450, shifting the center frequency of channel A 2 MHz to the left.
- 2 Upgrade sector D to PMP450, shifting the center frequency of channel D 2 MHz to the right.
- 3 Upgrade sector B to PMP450, shifting the center frequency of channel B 1 MHz to the left and changing the bandwidth of channel B from 7 MHz to 5 MHz.
- 4 Upgrade sector C to PMP450, keeping the same center frequency.
- 5 Change the center frequency of sector B by shifting it 1 MHz to the right, and change the bandwidth of sector B back to 7 MHz.
- 6 Move the center frequency of channel A 2 MHz to the right.
- 7 Move the center frequency of channel D 2 MHz to the left.

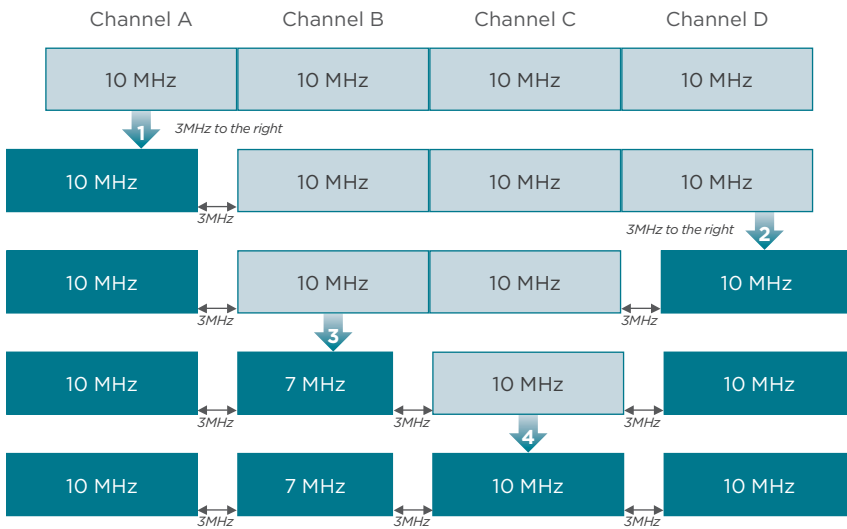
The original PMP320 deployment used a total of 28 MHz of spectrum, and so does the PMP450 deployment after migration. This is possible only if PMP450 limits the SM Tx power to 23 dBm in all sectors.

EXAMPLE 6
PMP320 WITH 4 X 10 MHz CHANNELS AND NO GAPS BETWEEN CHANNELS –
PMP450 SM TX POWER AT 25 DBM

Figure 10 shows the migration strategy for upgrading a PMP320 network using four 10 MHz channels (A, B, C and D) with no gaps between adjacent channels in the case the final PMP450 deployment allows SM Tx power up to its maximum value (25 dBm).

The migration of the PMP320 site to a PMP450 site can be done following these steps:

Figure 10 - Migration strategy for Example 6



Legend:

- PMP 320 (Light Blue)
- PMP 450 (Dark Blue)

- 1 Upgrade sector A to PMP450, shifting the center frequency of channel A 3 MHz to the left.
- 2 Upgrade sector D to PMP450, shifting the center frequency of channel D 3 MHz to the right.
- 3 Upgrade sector B to PMP450, shifting the center frequency of channel B 1.5 MHz to the left and changing the bandwidth of channel B from 10 MHz to 7 MHz.
- 4 Upgrade sector C to PMP450, keeping the same center frequency.

Because of the symmetry of the frequencies, an equivalent sequence of sectors to upgrade is D, A, C and B.

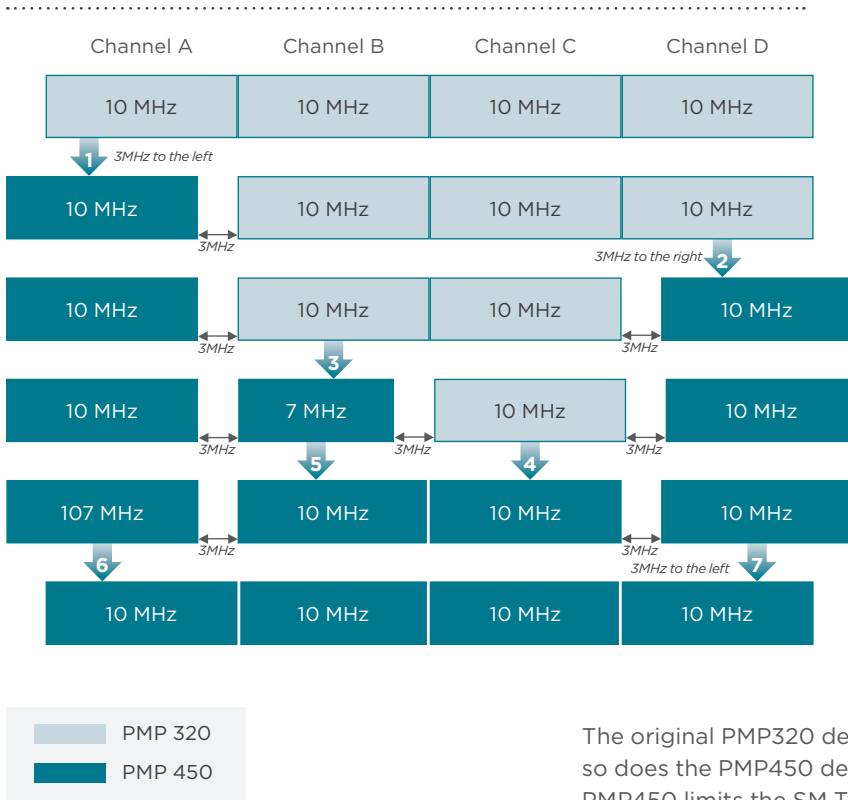
The original PMP320 deployment used a total of 40 MHz of spectrum, while the PMP450 deployment after migration uses 46 MHz of spectrum. This solution allows PMP450 to operate with 25 dBm Tx power in all sectors.

EXAMPLE 7
PMP320 WITH 4 X 10 MHZ CHANNELS AND NO GAPS BETWEEN CHANNELS -
PMP450 SM TX POWER AT 23 DBM

Figure 11 shows the migration strategy for upgrading a PMP320 network using four 10 MHz channels (A, B, C and D) with no gaps between adjacent channels in the case the final PMP450 deployment can use adjacent frequencies in adjacent sectors (SM Tx power limited to 23 dBm).

The migration of the PMP320 site to a PMP450 site can be done following these steps (note that steps 1 to 4 are the same as in Example 6):

Figure 11 - Migration strategy for Example 7



- 1 Upgrade sector A to PMP450, shifting the center frequency of channel A 3 MHz to the left.
- 2 Upgrade sector D to PMP450, shifting the center frequency of channel D 3 MHz to the right.
- 3 Upgrade sector B to PMP450, shifting the center frequency of channel B 1.5 MHz to the left and changing the bandwidth of channel B from 10 MHz to 7 MHz.
- 4 Upgrade sector C to PMP450, keeping the same center frequency.
- 5 Change the center frequency of sector B by shifting it 1.5 MHz to the right, and change the bandwidth of sector B back to 10 MHz.
- 6 Move the center frequency of channel A 3 MHz to the right.
- 7 Move the center frequency of channel D 3 MHz to the left.

The original PMP320 deployment used a total of 40 MHz of spectrum, and so does the PMP450 deployment after migration. This is possible only if PMP450 limits the SM Tx power to 23 dBm in all sectors.