

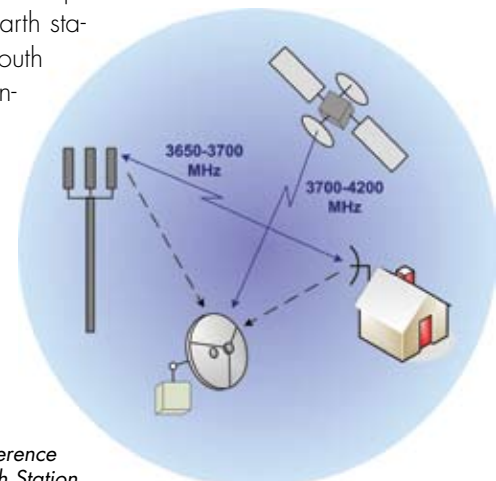
## Estimating the Required Separation Distances to Avoid Interference from Part 90 3650–3700 MHz Band Transmitters into C-Band Earth Stations

by Will Perkins,  
Principal Engineer

Calculations show a potential for transmitters in the new Part 90 3650-3700 MHz Band service to cause interference to earth station receivers in the adjacent 3700-4200 MHz C-band. As this new service is being established, earth station licensees and operators should be on the lookout for harmful interference effects from nearby Part 90 transmitters.

The FCC is issuing non-exclusive nationwide licenses for the 3650-3700 MHz band. Use of the band under these licenses requires registering fixed or base station locations in the FCC's ULS database. The rules also allow use of mobile or portable stations which must receive and decode an enabling signal from a fixed or base station in order to transmit. Transmitter EIRP density for base stations is limited to 1 W per MHz up to a maximum of 25 W per 25 MHz. For mobile or portable stations the limits are lower at 0.04 W per MHz up to a maximum of 1 W per 25 MHz. While mobile/portable transceivers could conceivably communicate at distances on the order of 20 km from a registered base station, in practice the radius of operation is likely to be smaller. Nevertheless to consider mobile/portable units, a radius from the base station locations registered in the ULS database must be used to assess the potentially affected earth station sites.

To estimate the path loss required from a Part 90 transmitter to an earth station receiver, and thus the separation distance for line-of-sight (LOS) conditions, it is necessary to know the gain of the earth station antenna towards the interfering transmitter. C-band earth stations communicate with geostationary satellites using high gain antennas directed towards the southern sky. In Part 25 the FCC prescribes limits for the off-axis radiation patterns that earth station antennas must meet. Orienting an earth station antenna towards a particular satellite involves setting the azimuth and elevation "look angles" of the antenna. To receive from a satellite at a longitude far to the east of the earth station location requires an azimuth just south of  $90^\circ$  and a low elevation angle. To receive from a satellite at a longitude far to the west of the earth station location requires an azimuth just south of  $270^\circ$  and a low elevation angle. Between these two extremes an earth station would use higher elevation angles and azimuth angles more to the south with the highest elevation angle occurring for a satellite at the same longitude as the earth station. To promote sharing with terrestrial services, Part 25 also limits the elevation angle an earth station may use to five degrees or greater. Generally, the smallest discrimination would occur if a Part 90 transmitter were on the same azimuth as the earth station antenna azimuth look angle. Then the off-axis discrimination angle would match the elevation look angle assuming an approximately horizontal direction towards the Part 90 transmitter. Taking this into



*Adjacent Band Interference  
into C-band Earth Station*

account along with the FCC pattern limits, the highest earth station antenna gain towards a Part 90 transmitter would normally be 14.5 dBi for the lowest elevation angle of five degrees. We can also consider higher elevation angles of 15° and 30° and the corresponding maximum gains of 2.6 dBi and -4.9 dBi, respectively. Finally, for angles greater than 48° off boresight, the FCC pattern requirement reaches a floor value of -10 dBi. Calculations for these gain values will give an assessment of the separation distances required for various conditions

Potential interference effects may be calculated for two phenomena—out-of-band transmitter emissions and LNB oversaturation. Table 1 and Table 2 show our distance calculations for interference via these two modes.

## Out-of-Band Emissions

In addition to the desired spectrum, transmitters emit low level signals outside the intended frequency range. These out-of-band emissions (OOBE) may appear as co-channel interference to an earth station receiver, so that receiver filtering could not be used to mitigate the interference. Although the Part 90 OOBE limit is a fixed value across the adjacent C-band, it should not be assumed that a transmitter would emit a constant out-of-band power spectrum at or near the limit. Instead, the OOBE would tend to be spurs affecting only particular frequencies or small ranges. Therefore this interference, if it occurs, should affect only certain transponder frequencies rather than the entire band. It will not be possible, however, to predict which transponder frequencies might be affected.

Part 90 Transmitter OOBE	ES Antenna Elevation	Part 90 Transmitter OOBE EIRP (dBW/MHz)	ES Receiver Total Noise Temperature (K)	ES Receiver Noise Power Level (dBW/MHz)	ES Receiver Interference Objective (dBW/MHz)	ES Antenna Off-Axis Angle (deg)	ES Antenna Gain towards Part 90 XMTR (dB)	Required Path Loss (dB)	Required Distance If LOS (km)
Poor	Minimum	-30	143	-147.0	-157.0	5	14.5	141.5	77.6
Poor	Low	-30	143	-147.0	-157.0	15	2.6	129.6	19.7
Poor	Typical	-30	143	-147.0	-157.0	30	-4.9	122.1	8.3
Poor	High	-30	143	-147.0	-157.0	48 or greater	-10	117.0	4.6
Typical	Minimum	-63	143	-147.0	-157.0	5	14.5	108.5	1.7
Typical	Low	-63	143	-147.0	-157.0	15	2.6	96.6	0.4
Typical	Typical	-63	143	-147.0	-157.0	30	-4.9	89.1	0.2
Typical	High	-63	143	-147.0	-157.0	48 or greater	-10	84.0	0.1

Table 1. Separation Distances to Ensure Non-interference from Out-of-Band Emissions (OOBE)

The FCC has set the power density that a Part 90 transmitter may produce in the adjacent 3700-4200 MHz band at  $43+10\log_{10}(P)$  (dB) below the transmitter power level P (W). This limit is applied in a 1 MHz bandwidth and thus the out-of-band transmitter power density limit is -43 dBW/MHz. Theoretically, a transmitter could be constructed to just meet this limit when operating at a low output power on the order of a fraction of a watt while using antenna gain to reach the Part 90 base station EIRP limits of 1 W/MHz up to a maximum of 25 W/25 MHz. In such a worst-case scenario the out-of-band emissions (OOBE) would be enhanced by the gain of the transmitting antenna and could result in interference at significant distances if line-of sight conditions were to exist. We estimate that the OOBE could be on the order of -30 dBW/MHz in this case. Fortunately the Part 90 radios that are being marketed as of this writing have OOBE that are significantly better than the FCC requirement. Measurements filed with the FCC show that these radios exceed the  $43+10\log_{10}(P)$  requirement by 20 dB or more even when operated with output power in the 1 W range. We believe that the carrier power to OOBE ratio should be maintained whether the transmitter is operated at full power or at a lower power. Therefore we estimate that the OOBE would typically be at -63 dBW/MHz or lower. Suppressing the OOBE to a greater degree than required by the rules goes a long way towards shrinking the separation distances. In our calculations we set the interference objective at an I/N ratio of -10 dB consistent with recommendation ITU-R SF.1006.

In Table 1 it can be seen that for the case of the current typical OOBE (-63 dBW/MHz), the separation distances to ensure non-interference range from 1.7 km if the earth station uses the minimum elevation angle, down to a minimum of 0.1 km which should apply regardless of angle. Since these distances depend on line-of-sight conditions, we expect any substantial path blockage to mitigate the interference concerns. We believe the typical -63 dBW/MHz OOBE level we have assumed is applicable to both Fixed/Base and Mobile/Portable transmitters. CPEs may use higher gain antennas than base stations, so the worst-case OOBE for mobile/portable transmitters may be even higher than -30 dBW/MHz. Let's hope the radios do not actually show such poor performance even though it is allowed by the rules.

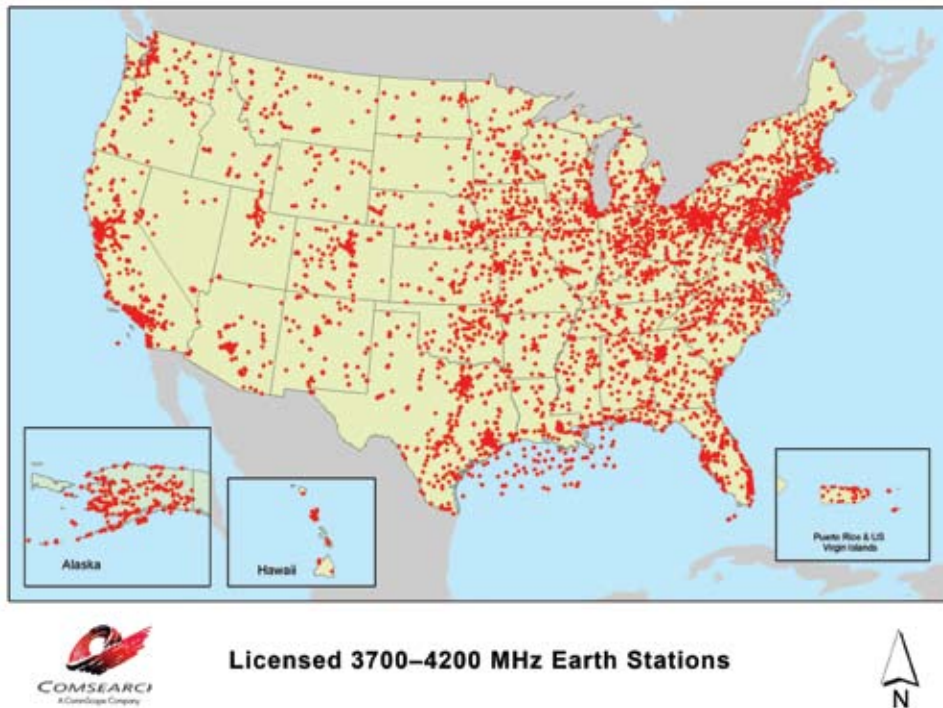
On reconsideration in the Part 90 3650-3700 MHz band rulemaking, the FCC stated the opinion that adjacent band interference could be analyzed with a third or fourth power dependence of path loss on distance, rather than the second power dependence for line-of-sight. On average over all the possible interference path distances, the FCC is very likely correct. However, here we are trying to identify cases where a Part 90 transmitter could cause interference by being located very close to an adjacent band earth station, and these short interference paths are much more likely to be line-of-sight.

Part 90 Transmitter Class	Part 90 Freq	ES Antenna Elevation	Part 90 Channel Center Freq (MHz)	Part 90 EIRP (dBm)	ES Antenna Off-Axis Angle (deg)	ES Antenna Gain towards Part 90 XMTR (dBi)	LNB Saturation Level (dBm)	Required Path Loss w/o Filter (dB)	Required Distance If LOS w/o Filter (km)	Typical Filter Selectivity (dB)	Required Path Loss with Typical Filter (dB)	Required Distance If LOS with Typical Filter (km)
Fixed/Base	Low	Minimum	3653.5	38.5	5	14.5	-55.0	108.0	1.61	23.2	84.8	0.111
Fixed/Base	Mid	Minimum	3675.0	38.5	5	14.5	-55.0	108.0	1.61	12.9	95.1	0.365
Fixed/Base	High	Minimum	3696.5	38.5	5	14.5	-55.0	108.0	1.61	2.6	105.4	1.197
Fixed/Base	Low	Low	3653.5	38.5	15	2.6	-55.0	96.1	0.41	23.2	72.9	0.028
Fixed/Base	Mid	Low	3675.0	38.5	15	2.6	-55.0	96.1	0.41	12.9	83.2	0.093
Fixed/Base	High	Low	3696.5	38.5	15	2.6	-55.0	96.1	0.41	2.6	93.5	0.304
Fixed/Base	Low	Typical	3653.5	38.5	30	-4.9	-55.0	88.6	0.17	23.2	65.4	0.012
Fixed/Base	Mid	Typical	3675.0	38.5	30	-4.9	-55.0	88.6	0.17	12.9	75.7	0.039
Fixed/Base	High	Typical	3696.5	38.5	30	-4.9	-55.0	88.6	0.17	2.6	86.0	0.128
Fixed/Base	Low	High	3653.5	38.5	48 or greater	-10.0	-55.0	83.5	0.096	23.2	60.3	0.007
Fixed/Base	Mid	High	3675.0	38.5	48 or greater	-10.0	-55.0	83.5	0.096	12.9	70.6	0.022
Fixed/Base	High	High	3696.5	38.5	48 or greater	-10.0	-55.0	83.5	0.096	2.6	80.9	0.071
Mobile/Portable	Low	Minimum	3653.5	24.5	5	14.5	-55.0	94.0	0.32	23.2	70.8	0.022
Mobile/Portable	Mid	Minimum	3675.0	24.5	5	14.5	-55.0	94.0	0.32	12.9	81.1	0.073
Mobile/Portable	High	Minimum	3696.5	24.5	5	14.5	-55.0	94.0	0.32	2.6	91.4	0.239
Mobile/Portable	Low	Low	3653.5	24.5	15	2.6	-55.0	82.1	0.082	23.2	58.9	0.006
Mobile/Portable	Mid	Low	3675.0	24.5	15	2.6	-55.0	82.1	0.082	12.9	69.2	0.019
Mobile/Portable	High	Low	3696.5	24.5	15	2.6	-55.0	82.1	0.082	2.6	79.5	0.061
Mobile/Portable	Low	Typical	3653.5	24.5	30	-4.9	-55.0	74.6	0.035	23.2	51.4	0.002
Mobile/Portable	Mid	Typical	3675.0	24.5	30	-4.9	-55.0	74.6	0.035	12.9	61.7	0.008
Mobile/Portable	High	Typical	3696.5	24.5	30	-4.9	-55.0	74.6	0.035	2.6	72.0	0.026
Mobile/Portable	Low	High	3653.5	24.5	48 or greater	-10.0	-55.0	69.5	0.019	23.2	46.3	0.001
Mobile/Portable	Mid	High	3675.0	24.5	48 or greater	-10.0	-55.0	69.5	0.019	12.9	56.6	0.004
Mobile/Portable	High	High	3696.5	24.5	48 or greater	-10.0	-55.0	69.5	0.019	2.6	66.9	0.014

Table 2. Separation Distances to Ensure Non-interference from LNB Oversaturation

## LNB Oversaturation

In most earth station receivers, a low noise block downconverter (LNB) is the first stage of electronics a signal encounters after the antenna. Many LNBs that are in service are not equipped with any filtering for the adjacent 3650-3700 MHz band. In addition while a filter may be added between the antenna and the LNB, there are practical limits as to how effective such a filter may be while at the same time passing unattenuated the desired C-band frequencies above 3700 MHz. A strong signal in the 3650-3700 MHz segment appearing at an LNB input could oversaturate the amplifier, causing reception problems for the entire 3700-4200 MHz band.



WiMAX radios will often use channels of 3.5 or 7 MHz bandwidth. Using the maximum allowed fixed/base EIRP density of 1 W/MHz, we find a total EIRP of 38.5 dBm for a 7 MHz bandwidth transmitter. Using the maximum allowed mobile/portable EIRP density of 0.04 W/MHz, we find a total EIRP of 24.5 dBm for a 7 MHz channel. Typical waveguide filters for television receive-only (TVRO) earth stations have a response that is -1 dB or less at 3700 MHz and rolls off to -25 dB at 3650 MHz. Because the effect of filtering, if used, is critical in determining the separation distances, we have conducted our calculations assuming a low, mid, and high frequency for the Part 90 transmitter. We again assume a 7 MHz bandwidth and thus channel center frequencies of 3653.5, 3675, and 3696.5 MHz. After convolution of a 7 MHz digital spectrum with a typical TVRO filter response curve, the selectivity the filter can provide against these frequencies are 23.2, 12.9, and 2.6 dB, respectively. To manage interference among the Part 90 terrestrial systems, the FCC requires the radios to use a contention-based protocol. The protocol is said to be unrestricted if it can avoid interference with any other system that is deployed. Otherwise if the protocol can only avoid interference with similar systems it is said to be restricted. Radios equipped with a restricted contention-based protocol are only permitted to operate in the lower half of the band 3650-3675 MHz while radios equipped with an unrestricted protocol can use the entire band. Because the only protocols that exist at this time are restricted, it is the 3650-3675 MHz segment that will come into use first, and the higher selectivity values will apply.

For the oversaturation calculations we have used an interference objective of -55 dBm which is a typical LNB input level to cause 1 dB compression. The power of the desired carrier(s) is likely to be significantly lower and thus its contribution to the total is negligible in the oversaturation calculation. Table 2 shows that without filtering,

the separation distances from base stations to ensure non-interference range from 1.6 km for earth stations using the minimum elevation down to a minimum of 0.1 km. For mobile/portable transmitters the distances range from 320 m down to 19 m.

With filtering, future base station transmitters using an unrestricted protocol could require distances from 1.2 km for earth stations using the minimum elevation down to a minimum of 0.07 km for interference at any angle. Restricted protocol base transmitters could require distances from 365 m down to 22 m.

With filtering, unrestricted protocol mobile/portable transmitters could require distances from 239 m down to 14 m, and restricted protocol mobile/portable transmitters could require distances from 73 m down to 4 m.

The same caveats about line-of-sight conditions on the interference path in the OOB discussion also apply to LNB oversaturation.

## Conclusion

Part 90 transmitters that are located close to adjacent C-band earth stations will be capable of causing harmful interference due to out-of-band emissions and/or LNB oversaturation. The FCC rules do not require frequency coordination of the adjacent bands; however, the FCC has reserved the right to require additional measures such as better OOB performance for the transmitters. Adding filters to the earth station receivers may help. To proactively protect their receivers, earth station operators should coordinate and register their 3700–4200 MHz R/O Antennas and monitor the registration activity in the FCC ULS database for nearby Part 90 transmitters. The range of look angles used by the earth station will influence the necessary search distance as suggested by Table 1 and Table 2. Also it must be noted that mobile/portable transmitters may be located a significant distance from the base locations registered in ULS. Allowance for this cell radius should be included in searching the site registration data.

If an earth station receiver is exposed to several approximately equal interference signals from Part 90 transmitters, the multiple exposure effect could in the future extend the necessary separation distances beyond those indicated in the tables.

### Additional mitigation steps that may be considered are:

- Use of LNBs with greater dynamic range to reduce the likelihood of oversaturation. To date such products do not appear to exist but the interference potential from Part 90 transmitters may spur development even at higher price points.
- More effective earth station receiver filtering such as increased roll-off slope or beginning to roll off above 3700 MHz if the lowest transponder frequency does not ever need to be used.



For more information on protecting your earth stations, please contact Denise Finney at 703.726.5650 or [dfinney@comsearch.com](mailto:dfinney@comsearch.com).

[www.comsearch.com](http://www.comsearch.com)

Visit our Web site or contact your local Comsearch representative for more information.

© 2008 CommScope, Inc. All rights reserved.

Comsearch is a trademark of CommScope. All trademarks identified by ® or ™ are registered trademarks or trademarks, respectively, of CommScope. This document is for planning purposes only and is not intended to modify or supplement any specifications or warranties relating to Comsearch products or services.

TP-102516-EN (3/08)