700 MHz A Block
Good Neighbor Policy

For
Utilities Technology Council (UTC)

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Presented By

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700 MHz A Block Good Neighbor Policy

Introduction

This policy document is meant to be a guideline of practices for all users of the 700 MHz 'A' block spectrum to help alleviate interference with other nearby users.

The 700 MHz 'A' Block spectrum is a valuable resource that offers licensees substantial flexibility and freedom of development of their own networks. With any level of freedom however, comes a concurrent obligation to be a good neighbor. Beneficial occupancy of one licensee must not come at the expense of the beneficial occupancy of a neighboring licensee.

The FCC rules have limits, and when conflicts between neighbors arise, the expectation is that the parties involved will resolve the conflict between themselves. Only when this process fails will the FCC step in and become the arbiter of last resort.

This is summarized in 47CFR27.64: Wireless Communications Service (WCS) stations operating in full accordance with applicable FCC rules and the terms and conditions of their authorizations are normally considered to be non-interfering. If the FCC determines, however, that interference which significantly interrupts or degrades a radio service is being caused, it may, after notice and an opportunity for a hearing, require modifications to any WCS station as necessary to eliminate such interference.

Background

The planning and construction of facilities in geographically licensed spectrum is not routinely served by the frequency coordination community. As such, there is currently no central database of 700 MHz 'A' Block transmitters available for planning such as exists in the site licensed bands.

Planning is complicated by the fact that no common channel plans exist for this band, so each user is completely free to construct their own.

The result is that licensees in adjacent MEAs (as defined by the FCC) have no alternative but to devote considerable resources planning their networks to meet their needs, while avoiding interference into or from facilities in neighboring MEAs. Considering how dynamic these networks tend to be, this is an ongoing resource allocation problem for both parties.

These realities are the driving forces behind the need for a good neighbor policy document.

UTC Standard Channel Plan

The standard UTC channel plan for the 700 MHz 'A' block is detailed in Appendix A.

Benefits of a UTC Standard Channel Plan

The benefits of using a standard channel plan are substantial:

- If multiple licensees adopt the UTC standard channel plan, frequency coordination among participating licensees will be much easier
- Interference conflicts can be avoided before expensive equipment installations are constructed
- Where broadband services are required, contiguous channels at the lower end of the block could be aggregated to support that service, while allowing the rest of the plan to stay uniform with the standard plan

More information regarding the technical details and radio technology choices that should be considered while using the channel plan can be found in Appendix B.

FCC Rules

The FCC rules apply to portions of the 700 MHz 'A' block. These rules address the following areas:

- Field strength at the license boundary
- Transmit ERP levels
- Rural area fixed and base station coordination
- Out of Band Emissions (OOBE)

Details of the rules that apply in each of these areas is discussed in Appendix B.

Geographic Considerations

There are several steps that can be taken in consideration of an adjacent MEA to help minimize interference. These are listed as "Good Neighbor Practices". Practices to avoid are listed as "Bad Neighbor Practices".

Good Neighbor Practices

- Use PMP applications with low transmit powers, low antenna heights and the maximum possible frequency reuse of the spectrum
- For sites near license area borders, use shaped antennas with high front/back ratios to minimize interference into co-channel and adjacent channel neighbor sites
- Where possible, use fiber optics or site-licensed shared microwave bands to facilitate backhaul between PMP sites
- Minimize use of PTP links. When 700 MHz PTP links are required, use low-beamwidth antennas to minimize side lobes
- Keep antennas as low as possible to minimize the risk of ducting
- Coordinate site locations and technical parameters with neighbors
- Utilize Automatic Transmit Power Control (ATPC), adaptive modulation, and polarization to minimize interference effects
- Perform intermodulation analysis when neighbors are sharing a common tower or located on towers located less than 1 Km from one another
- Perform radiation hazard analysis any time an antenna is low enough on a tower to be a hazard to nearby populated areas/structures

Bad Neighbor Practices

- Implementation of PTP applications where the risks of ducting into adjacent neighbor's service territories are significant
- Placing antennas on towers higher than necessary
- Setting all transmitters to max power
- Exceeding field strength contours at license borders through careless use of broad beam antennas
- Generation of interfering intermodulation products affecting neighbor antennas on shared towers

Additional information regarding technical details and radio technology choices that should be considered near geographic boundaries can be found in Appendix D.

Appendix A

UTC Standard Channel Plan

A channel plan incorporating five wideband (100 KHz) and 25 narrowband (25 KHz) channels is proposed as a UTC standard. This is shown in Figure 1.

Low Side (757-758 MHz)																									
Channel Size	100	25	25	25	25	100	25	25	25	25	100	25	25	25	25	100	25	25	25	25	100	25	25	25	25
Channel Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
High Side (787-788 MHz)																									
Channel Size	100	25	25	25	25	100	25	25	25	25	100	25	25	25	25	100	25	25	25	25	100	25	25	25	25
Channel Number	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	47	49	50

Figure 1- UTC Standard Channel Plan for the 700 MHz ‘A’ Block

Appendix B

Channel Plan Technical Information

Intermodulation Analysis

Analysis of intermodulation effects of channels from the plan will help minimize interference.

Intermodulation is the amplitude modulation of signals containing two or more different frequencies, and derives from nonlinearities in a system. The intermodulation between each frequency component will form signals at frequencies that are at the sum and difference frequencies of the original frequencies and at multiples of those sum and difference frequencies. These become a form of interference, that must be avoided whenever possible within a channel bandwidth.

The type of intermodulation primarily of concern is called third order. This implies the calculation of intermodulation products involving three frequency components such as (F1 + F2 – F3) where F1, F2 and F3 are frequencies being transmitted in close proximity to one another.

Channel planning is based on consideration of third order intermodulation products. Standard practice in developing a channel plan is to start with the spectrum purchased, and partition it into desired channel sizes, keeping wider channels at the lower frequencies to the extent possible.

However, to derive useful benefits requires an analysis of intermodulation effects and stipulate combinations of channels from the plan that allow multiple transmitters near to one another without intermodulation products falling inside any of the channel bandwidths.

Frequency Division Duplex (FDD) and Time Division Duplex (TDD)

Both FDD and TDD access technologies provide for two-way (duplex) communications. In the case of FDD, separate uplink and downlink channels imply low latency communications, and allow transmitters at both ends of a communications link to operate simultaneously. By contrast, TDD allocates time for the transmitter at one end of the link, followed by a period when the other transmitter operates. There can be no simultaneous transmissions between the two and the latency of the link increases.

- FDD requires double the amount of spectrum required by TDD
- When planning channel assignments to specific towers, or attempting to avoid conflicts with nearby towers, the choice of channel combinations is limited to those intermodulation-free combinations of channels used by transmitters at each end of the link
- Depending on the amount of isolation required by the licensee between the channel center frequency and the nearest intermodulation product, this can be restrictive to the number of available channels. For the UTC standard plan, when all channels are selected from one side of the band, with the FDD assumption that each channel has a mirror in the other side of the band, there are only about 330 possible combinations of channels from which to choose.
- By comparison, TDD channel combinations can include channel frequencies from both sides of the band. For the UTC standard plan, a comparable number of possible channel combinations is over 10,000. This allows a much higher level of frequency reuse in wireless network implementation, and support for much larger networks.
- The application being served is a major factor in deciding which access technology to use
    - For high speed switching where latency is a major factor, or for DMR systems, FDD may well be the appropriate choice
    - For most distributed automation requirements of capacitor banks, Volt/Var controls, and reclosers, TDD is the logical choice. This is especially true when a utility is the client, and their service area and/or client base will require a large network with substantial frequency reuse.

Appendix B

FCC Rules

Field Strength at the License Boundary

The field strength at the boundary of the license as defined by 47CFR27.5(2) calls out maximum limit of 40 dBu for the lower half of the frequency band, 757-758 MHz. There are no corresponding restrictions on the band 787-788 MHz.

This limit is permitted to be raised if both parties agree per 47CFR27.15(b)(4). Good neighbor policy would be for two parties in adjacent MEAs to negotiate a formal document specifying a maximum limit exception as allowed, and any other points to which both could agree. One example might be that each party would agree to maintain maximum antenna heights below the expected ABL in that area. Another might be to allow higher cross-border emission levels in areas such as farmland where the likelihood of interference would be lower.

One approach might be for UTC to undertake the drafting of such a document that could be provided to 700 MHz 'A' Block licensees, and presented to licensees as a template to move such an agreement forward.

Transmit ERP Levels

Transmit ERP levels in the band 757-787 MHz are specified in 47CFR27.50(b)(1) as 1000 watts for antennas at or below 305 m above the HAAT, while 47CFR27.50(b)(9) limits the ERP of fixed stations, control stations[1] and mobile stations to a maximum ERP of 30 watts.

This seems restrictive, but for Distribution Automation (DA) applications, most of the radios have a maximum 10 watts output power. With a reasonable cable loss and most antennas, the ERP of 30 watts is a natural fit.

Portable transmitters are allowed in upper half of the 'A' block, with a limit of 3 watts ERP.

Rural Area Fixed and Base Station Coordination Requirements

In this block of spectrum, there are requirements for users of adjacent bands to the 700 MHz 'A' block in rural counties for coordination with both surrounding 'A' block users and regional planning commissions.

[1] A station at a fixed location that communicates with mobile stations and other control stations through repeater stations, and may also be used to control the operation of repeater stations. https://www.law.cornell.edu/cfr/text/47/95.303

To maintain control over adjacent channel emissions into their MEAs, licensees will need to respond to these coordinations. But to do so, each 'A' block licensee will need to maintain a database of all base station locations and provide that as necessary for coordination in this band.

Consequently, a mechanism to support the coordination process is needed to help maintain the value of spectrum holdings of each licensee.

Rural areas are defined as consisting of counties with population densities of less than 100 people per square mile. At the time for license renewal, when Safe Harbor calculations are presented, the FCC requires the 2010 census data mapped into 1990 County Equivalent contours for these definitions.

47CFR27.50 (b)(7) (i) requires coordination by adjacent channel licensees with any 700 MHz 'A' block licensee operating within 75 miles of each proposed base station or fixed station. While the 'A' licensee has no obligation to respond to these coordinations, not to do so will put their systems at risk from cross-border adjacent channel interference.

47CFR27.50 (b)(7) (ii) requires coordination by adjacent channel licensees in advance with regional planning committees with jurisdiction within 75 miles of each proposed 'A' block base station or fixed station. While the rules specify the planning committees as identified in 47CFR90.527. That paragraph spells out the requirements for regional planning committees, but does not specifically identify them. However, the FCC maintains a database of them on their website at the following URL.

https://www.fcc.gov/general/700-mhz-rpc-directory-0

In accordance with 47CFR27.57(b), licensees in the 'A' block are subject to current and future international agreements between the United States and Canada and the United States and Mexico. Unless otherwise modified by international treaty, licenses must not cause interference to, and must accept harmful interference from, television broadcast operations in Mexico and Canada, where these services are co-primary in the band.

Out of Band Emissions (OOBE)

Out of band emissions are addressed in 47CFR27.53(c) (1 & 2), and specify that any emission shall be attenuated outside the band below the transmitter power (P) by at least 43 + 10 log (P) dB.

This is not an issue for the radio manufacturers, but is not adequate in some system designs due to radio sideband noise, especially if the sideband noise is not attenuated further in multiple adjacent channels.

Generally, radios using a form of PSK modulation perform better in this situation than radios using FSK.

When sectorizing antennas to minimize in-band cross-border emissions, it will often be necessary to have high-gain, narrow-beamwidth antennas mounted at different azimuth angles but at the same elevation on a tower.

In this situation, even with high performance antennas, if the antennas are on different channel frequencies, the antenna isolation may not adequate to avoid internal adjacent channel interference. In such cases, the system design will depend on additional radio isolation for channels well removed from one another.

If that isolation is not available from the radio being used, the alternative is to add external filters. These take up valuable space in the equipment shed, add insertion losses, and raise the cost of the installation.

There is an emissions limit from the first harmonic of 'A' block transmitters falling in the band 1559-1610 MHz. These must be limited to −70 dBW/MHz equivalent isotropically radiated power (EIRP) for wideband signals, and −80 dBW EIRP for discrete emissions of less than 700 Hz bandwidth.

Appendix D

Geographic Considerations

General Design Guidelines

- Downtilting of an antenna limits the range of propagation of the main beam, and will reduce interference levels beyond the intended coverage areas. This is an option for PMP, and less so for PTP links where the main beam will be focused on the antenna at the other end of the link.
- Sectorizing of a base station site allows the use of higher performance, lower beamwidth, lower side-lobe antennas that can be pointed in directions of desired coverage, while minimizing energy to areas of less interest. Even when only a single channel is available, this is a prudent policy.
    - L&W recently designed and supervised construction of a large smart grid wireless network using this approach. In that case, each antenna was cabled to the shelter on the ground and combined using a passive combiner-splitter.
    - This design approach also gave the client the ability to expand their system to multiple channels on that site as traffic loads grow and additional spectrum becomes available, while still maintaining cross-boundary interference levels
- Sectorizing is particularly appropriate when a base station site is near the border of the license area, as the lower beamwidth of the sector antennas supports compliance with the 40 dBu maximum field strength requirement of 47CFR27.55(2)
- A good neighbor policy is to also follow the 40 dBu maximum field strength requirement of 47CFR27.55(2) in the upper half of the band (787-788 MHz) as well, even though the FCC does not require it

Point-to-Point (PTP) and Point-to-Multipoint (PMP) Links

Generally, PTP links should not be implemented in auctioned spectrum, especially when antenna elevation height above the average terrain (HAAT) are such that ducting becomes an issue. Ducting is a two-way long-distance phenomenon, and can create interference problems far beyond the boundaries of a geographical license.

When PTP links are required in the 700 MHz ‘A’ Block, the recommended configuration is TDD, even though most PTP applications are FDD. With a TDD link, if interference occurs, the damage will be limited to a single channel.

When a client is using both PTP and PMP applications on the same tower, vertical antenna spacing becomes critical between their relative antennas, especially when the channels being used are less than 200 KHz apart.

Automatic Transmit Power Control (ATPC)

ATPC ensures reliable transmission in longer links with significant fading/ducting. It is also helpful in mitigating rain fades in higher frequency bands, but weather effects at 700 MHz are minimal. The primary benefit at 700 MHz is the ability to keep transmit powers low on PTP links, except in fading/ducting conditions, and minimizing interference into co-channel neighboring sites.

Adaptive Modulation

Adaptive modulation provides the ability to modify the modulation type of a link, and can be either static or dynamic. For PTP applications, it allows shifting to higher order modulation types in order to increase the data throughput, depending on the quality of the link at any instant.

In PMP applications, adaptive modulation allows a trade-off between bandwidth and range for the link from a base station to a particular end-point.

Polarization

Polarization is used extensively in PTP applications to provide a level of isolation that allows multiple channels to operate over a common link. Horizontal, Vertical and Circular polarizations are widely used.

In PMP applications, Vertical polarization is the most widely used as it allows omni and other tall antenna structures to extend vertically, minimizing the difficulty of antenna- tower mountings, and keeping the antennas from becoming effective perches for birds.

Ducting

Temperature inversion is a common cause that influences how ducting occurs. Warm air is normally found closer to the surface of the earth, with a band of cool air above it at increased altitudes. However, on occasion, when atmospheric conditions are right, a band of warm air forms above the band of cool air, creating a duct. Wind shifts can also drive ducting.

If the signal enters the duct at a very low angle of incidence, the resulting propagation may extend far beyond normal Line of Sight (LOS) distances. These extended distances result because of the different densities and refractive qualities of warm and cool air. The sudden change in density when a radio wave enters the warm air above a duct causes the wave to be refracted back toward Earth. When the wave strikes the Earth or a warm layer below the duct, it is again reflected upward and proceeds on through the duct, potentially with multiple hops. The result is an effective reduction in the path loss.

Given that ducting is an atmospheric phenomenon, both PTP and PMP systems are susceptible. Low transmitter powers, and mounting antennas lower to average terrain will help mitigate the effects.

Considering that adjacent MEAs can be affected when ducting occurs, good practice in the 700 MHz A Block is to minimize the number of high sites and transmit power levels to the maximum possible extent.

Over the years many papers have been written describing the likelihood of ducting occurring in a given area, but currently there are no generally accepted engineering guidelines for mitigation. Here are some recommendations from a couple of recognized RF propagation experts that address this problem as it applies to PTP links:

"The best defense against ducting fades is essentially the same as for obstruction fading: tall towers on short paths. If that is not possible, other approaches can help. A high-low path with large launch angles (at least one degree) is one approach. Orienting an antenna slightly up or down can help. Another approach is to use space diversity with main-to-main and diversity-to-diversity radio paths as parallel to the terrain as possible. Using smaller antennas (to increase radio vertical beam width) may help. Sometimes very high main and very low diversity antennas are effective for unusual situations such ducting over large bodies of water. Currently path engineering in a ducting environment is based upon experience more than science."[2]

"Good pre-emptive path engineering, e.g. the assignment of adequate path clearances that respect the region's geoclimatic conditions, is most important in minimizing the occurrence of duct power fades. The only certain corrective actions that will mitigate power fading caused by duct entrapment in a waveguide-like Atmospheric Boundary Layer (ABL) are typically costly - an increase in fade margin ("blast" through the duct), more path clearance (possibly higher towers), shorten the path, change from a flat (<0.5deg inclination) to a high-low path, or reroute it around its adverse ducting atmosphere, the latter three likely requiring a new repeater site. It is, however, essential that before such a costly undertaking, all larger main and diversity antennas be uptilted 1-2 dB to accommodate k-factor variations with nighttime temperature drops."[3]

[2] Digital Microwave Communication: Engineering Point-to-Point Microwave Systems, First Edition. George Kizer. ©The IEEE, Inc. Published 2013 by John Wiley & Sons, Inc.
[3] PCR v.6.0.3 HISTORY DATA VIEWER FOR MICROWAVE HOP PERFORMANCE ANALYSIS AND OPTIMIZATION. Aviat Networks Doc. No. 228. Dick Laine. August 29, 2011