6 SUMMARY OF MEASUREMENT RESULTS

The measured data presented in this report characterizes channel usage of LMR systems operating in the 162–174 and 406–420 MHz frequency bands in the Washington, D.C., area. The analysis of the data is used to present the percent usage for a typical or representative channel during an 8-day measurement period using sampling procedures for the measurements.

A summary of the measurement results for channel usage for each band is given in the following sections along with a description of the diurnal patterns. There are several limitations to the measurements, however, that need to be considered, as follows.

Because the measurement system coverage area for mobile and portable stations is not as extensive as for base stations and repeaters, and because terrain and structural obstruction may prevent adequate reception of these mobile radio signals by the measurement system, the usage statistics may not fully reflect the usage within the bands. However, for each transmission by a portable or mobile station there is usually a corresponding transmission response from a base station or repeater that reflects that usage; therefore, for the worst case, where no portable and mobile station transmissions are detected, the measured usage would need to be doubled (assuming no talk-around). In reality, the usage statistics lie somewhere in between these two extremes, since some of the signals from mobile and portable stations were detected by the measurement system. It is also possible that the measurement system coverage area for base stations is extensive enough to detect frequency reuse, thus reflecting a higher than expected average usage.

There are some assignments that, while included in the overall statistical analysis, in reality are not used for LMR transmissions or cannot be detected. Some cannot be detected for the reasons described in the previous paragraph. The received power from some assignments may be below the measurement system sensitivity. Some channels may be assigned for “listening only” in the sense that they infrequently carry traffic but are monitored continually for emergency transmissions. In every case, the result is that the usage statistics may show usage less than what would be expected if the analysis were performed only on channels that are reserved for transmission and can be detected within the measurement receiver coverage. Furthermore, any 12.5-kHz channel that has a wideband assignment adjacent to it cannot generally be used within the measurement system coverage area, and therefore would not show any activity.

Only 2 out of 36 hydrology channels in the 162–174 MHz band exceeded 80 percent usage and therefore were excluded from analysis – when HOCs were excluded (see Section 5.4). None of the 12 hydrology channels in the 406–420 MHz band exceeded the 80 percent usage level and therefore, none were excluded from analysis. This means that the hydrology channels with less than 80 percent usage (some with very little, if any, usage) were included in the overall LMR occupancy statistics. Upon closer examination, it was determined that the non-HOC hydrology channels in the 162–174 MHz band had a mean usage of 3.7% and the non-HOC hydrology channels in the 406–420 MHz band had a mean usage of 5.1%. Because the non-HOC

hydrology channels are few in number and the mean usage values are only slightly above the overall LMR band usage, they had little effect upon skewing the results upward.

While every effort was made to minimize the effects of noise, as described in Section 4.1, there were occasional periods when impulsive noise raised the power in the entire band enough for individual channels to exceed the detection threshold but not high enough to be identified as corrupted data and discarded from the analysis. It is difficult to determine precisely how often this occurred but it may have occurred enough to skew the mean usage values somewhat towards higher than expected usage values.

Much of the data presented in this report is represented in the form of "mean usage" which is meant to convey "typical" usage by a channel. However, because the percent usage statistics are not Gaussian distributed, and because, as shown in Figure 34, there are a few channels with relatively high usage (20 percent of the channels with greater than 2 percent usage) but far more channels with relatively low usage (80 percent with less than 2 percent usage) the mean is skewed, due to outliers, towards a larger value than what one might think of as "typical." This is because the overwhelming majority of usage values are around 1-3% but there are individual values much greater than this that tend to computationally bias the mean to a higher value. In this case, the median may be more representative of what is a "typical" channel usage and can be extracted from the cumulative distribution plots as described in Section 5.6.

Because most of the channels in these bands are statically assigned to networks or individual users, as opposed to dynamically assigned as is the case with trunked systems (see Definitions), many of these channels are reserved for high priority usage in which communication must be available at all times for a limited number of users. It should also be noted that agencies may have channel usage that deviates from these values – either to a greater or lesser extent. Likewise, none of these measurements were made during a major emergency that might have greatly increased the use of radio channels.

The channel occupancy measurements in this report provide a measure of the level of communications traffic in the 162–174 MHz and 406–420 MHz LMR bands. The results can be used for specifying the overall performance objectives of a hypothetical communications system using a different technology (e.g., trunking). By designing the hypothetical system to provide the same overall communications capability as the existing LMR systems, the existing and hypothetical systems could then be compared to examine relative total spectrum usage (number of channels required for each system).

The intent of the measurements was not to examine details of performance and use for the characterization of individual channels. This individual channel information, as well as more extensive measurements, may be required for a detailed engineering design for a next generation system.

6.1 Overall Results

Hourly Band Usage within the measurement system coverage area varies between 0.3–3.8% (Figures 26 and 38) for the two measured bands, but show the busiest hours to be between 7 AM and 5 PM, with the minimum usage near midnight. Results also show that the newly created 12.5-kHz channels are not yet used as much as the old 25-kHz channels. Note that these are average statistics, and usage for individual channels and agencies may deviate significantly (higher or lower) from the overall band usage.

6.1.1 Results for 162–174 MHz Band

For a mean detection threshold of -113 dBm, in the 162–174 MHz band (HOCs excluded), *Band Occupancy by Time-of-Day* within the measurement system coverage area is between 0.6–1.6% for all channels spaced 12.5 kHz apart, 0.9–2.2% for the old 25-kHz channels, and 0.2–1.2% for the new 12.5-kHz channels (see Figure 30). The highest value of the *Band Occupancy by Time-of-Day* represents the *Maximum Band Occupancy*, which is 1.6% for all channels spaced 12.5 kHz apart and includes both Specific Location and Area frequency assignments. When the *Maximum Band Occupancy* for channels spaced 12.5 kHz apart is calculated based on only the Specific Location assignments, the value is 2.1 percent.

The *Band Occupancy by Time-of-Day* for conventional LMR systems can be compared to allowable call-blockage (typically referred to as Grade of Service) as recommended in the Final Report of the PSWAC. In that report the committee recommends that blockage not exceed “one call for service per one hundred attempts during the average busy hour.” That translates to no more than 1 percent usage for multi-user conventional systems where channels are assigned statically. Since the systems measured in the 162–174 MHz band are conventional systems, the measured usage during the busiest hour of 1.6 percent is relatively consistent with the recommendations by the PSWAC. [9]

For a mean detection threshold of -113 dBm, the overall *Percent Band Usage* for the 162–174 MHz band (HOCs excluded) during weekdays is 1.11% over a 24-hour period, 1.53% between 8 AM and 5 PM, and 3.14% for the *Average of Busiest Usage by Hour* (see Table A-2). For *Busiest Usage by Time-of-Day*, 60% of the channels exceed a usage of 1%, while 10% of the channels exceed 7%, and 1% of the channels exceed 34% (see Figure 34).

6.1.2 Results for 406–420 MHz Band

For a mean detection threshold of -117 dBm, in the 406–420 MHz band (HOCs excluded), *Band Occupancy by Time-of-Day* within the measurement system coverage area varies between 1.3–2.7% for all channels spaced 12.5 kHz apart, 2.2–4.1% for the old 25-kHz channels, and 0.4–1.5% for the new 12.5-kHz channels (see Figure 42).

For a mean threshold level of -117 dBm, overall *Percent Band Usage* for the 406–420 MHz band during weekdays is 2.08% over a 24-hour period, 2.67% between 8 AM and 5 PM, and 4.29% for the *Average of Busiest Usage by Hour* (see Table A-6). For *Busiest Usage by Time-of-Day*, 44% of the channels have a usage that exceeds 1%, while 10% of the channels exceed 13%, and 1% of the channels exceed 60% (see Figure 46).

6.2 Diurnal Patterns for Both Bands

Each of the two bands show about the same diurnal pattern of usage, irrespective of the whether they were measured for all days, weekdays, weekends, or Election Day (see Figures 29 and 41). However, there are slight variations between the bands. In the 162–174 MHz band, the highest usage occurs during the weekdays, exceeding the other time scenarios by about 1%. The other time scenarios show about the same usage except for about a 0.5% less usage in the midday for Election Day. In the 406–420 MHz band, the usage is about the same for all of the time scenarios, except for about a 1% less usage on the weekend mornings, and about a 1% greater usage on the afternoon of Election Day.

For both bands, the times and dates for *Busiest Hour of the Week for Each Channel* (see Definitions) are distributed fairly evenly over time-of-day and day-of-week, with the exception that busiest hours are broadly grouped more in the daytime hours (see Figures 27 and 39). There are a few occurrences where blocks of adjacent frequencies appear to have the busiest hour all at the same time. However, such occurrences are not typical. Whenever large numbers of adjacent frequencies appear to become busy at the same time, there is a possibility that the measurements were being affected by broadband RF energy, radiated intentionally or accidentally.

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