In the Matter of Notice, and Request for Comments on Phase II/III of the Spectrum Sharing Innovation Test-Bed Pilot Program.	)))))	 NTIA Docket No. 120322212-2212-01

Comments of Motorola Solutions, Inc.

Motorola Solutions, Inc (MSI) appreciates the opportunity to respond to the NTIA's Notice and Request for Comments on Phase II/III of the Spectrum Sharing Innovation Test-Bed Pilot Program[1]. We hope that the NTIA will find these comments helpful when finalizing the Phase II and Phase III test plans for this important research into the possible use of Dynamic Spectrum Access (DSA) techniques for facilitating the sharing of spectrum between Land Mobile Radio (LMR) systems and DSA-enabled devices.

MSI supports the continued testing and evaluation of DSA-enabled devices, in order to better characterize their operation, and to understand the issues that must be addressed before DSA can be used as a mechanism to enable the efficient sharing of spectrum while avoiding harmful interference to incumbent systems. DSA technology is still in its relative infancy, and highly controlled spectrum sharing test beds are crucial to furthering our understanding of the operation of these devices, in order to mature the technology.

MSI recognizes the important work that the NTIA has already undertaken in this regard, through the deployment and testing of its Phase I test-bed. In the comments that follow, MSI provides input on multiple aspects of the Phase II and Phase III test-bed proposals. These

[1] *Spectrum Sharing Innovation Test-Bed Pilot Program*, National Telecommunications and Information Administration, 77 Fed. Reg. 18793 (March 28, 2012).

comments address the topics of spectral sensing, detecting hidden nodes, and adjacent channel interference, among others. We hope these comments will assist the NTIA as it completes the Phase II and Phase III planning for this test-bed, in preparation for moving forward with its DSA evaluation.

I. Spectral Sensing

The addition to the test-bed of highly mobile incumbent systems, especially the inclusion of low power portable incumbent transmitters (i.e., LMR portables), requires significant additional measures for adequate incumbent protection, including but not limited to extremely sensitive spectral sensing mechanisms. Due to the significantly different propagation paths that may exist between the incumbent LMR transmitter and DSA sensor, and between the LMR transmitter and LMR receiver, an additional sensing margin of 30-50dB over typical reference sensitivity levels for LMR receivers (which are typically in the range of -120dBm for Project 25 base station receivers) may be needed. Some of the many real-world effects that cause significant path loss differences include natural shadowing features (e.g., due to terrain, foliage, etc.), man-made shadowing features (e.g., due to buildings), multipath signal fading, low antenna heights and gains, antenna pattern losses (including body losses), and polarization mismatches, among others. The cumulative result of all of these effects can add up to 30-50dB or more of path loss difference, which points to required LMR incumbent sensing levels in the range of -150dBm or lower. Note that TV White Spaces (TVWS) DSA equipment originally utilized a recommended sensing level of -114dBm, which was 30dB below typical Digital TV (DTV) receiver sensitivity levels, and that was for fixed receivers with outdoor antennas. In order to fully evaluate DSA technology, it is very important to test DSA spectral sensing performance over a wide variety of different real-world operating conditions (i.e., different DSA and LMR antenna heights/polarizations, body losses, indoor/outdoor locations, in hilly terrain and mountainous terrain, etc.).

II. Testing for Hidden Nodes

The well known hidden node problem is a very challenging issue, which can only be partially solved by mechanisms such as cooperative sensing. Of particular concern is the case where the cooperative sensor results are highly correlated (such as when the sensors are in similar locations with respect to the incumbent transmitter), which often results in a loss of the cooperative sensing advantage. One example of this is when a direct mode LMR transmitter is located in the basement of a building, and all of the cooperative sensors are located several kilometers away, with the result that all see relatively similar incumbent signal profiles. When combined with the fact that LMR receivers can be located anywhere (including outside of normal base station coverage areas when utilizing direct mode communications), the problem gets to be very challenging for both spectrum sensing and geo-location database incumbent protection techniques. It is critically important to test both LMR uplink (inbound) and downlink (outbound) weak signal hidden node cases, as well as direct-mode (unit-to-unit) communications cases, since they will all undoubtedly occur in the field. Hidden nodes will occur more often with low-power portable transmitters (with low antenna heights and gains, as well as fairly random antenna polarizations and patterns). All of these cases should be thoroughly tested under a variety of environmental operating conditions as described above.

III. Adjacent Channel Interference

It is also important to maintain the correct sensing performance while the DSA system is fully operational (e.g., during normal data transmissions), and in the presence of strong interferers, such as strong adjacent channel interferers. For example, some real-world interfering signals from base stations in the Specialized Mobile Radio (SMR) band have been measured at levels as strong as -10dBm (in band). Project 25 LMR base station receivers are required to operate with a 60dB stronger adjacent channel signal (at 3dB above sensitivity, as specified in TIA 102.CAAA-C), and many receivers operate at levels significantly better than that requirement. These results require very good LMR transmitter out-of-band emissions (OOBE) performance levels, which are typically in the range of -67dBr or better. DSA transmitters should have OOBE (splatter levels) that are at least this good. It is important to realize that actual Project 25 equipment operating performance is often better than the TIA standards requirements, and better than test equipment can measure without highly modified test systems. Failing to take this into account may result to interference to LMR systems, which can be especially harmful for mission critical communications.

In addition, in any multicarrier DSA scheme, particularly those utilizing discontinuous carriers, it is important to look at the spurious and intermodulation distortion products that are generated by such approaches, since these may be significant enough to overwhelm weak LMR signals (e.g., at -120dBm reference sensitivity levels). This is especially important for DSA systems that attempt to notch out sections of spectrum that are utilized by incumbents. These problems can become even more pronounced at high gain levels in both the DSA transmitter and receiver, and may even de-sense the DSA device's incumbent sensing algorithms in practice. Therefore, it is important to fully characterize the DSA device's full spectral output (including out of channel spurious emissions) while operating in all conditions, as well as to fully test the spectrum sensor under all expected radio operating conditions. The effects of DSA adjacent and alternate channel transmissions (at all possible frequency offsets) should be fully evaluated to understand the effects of all DSA emissions.

It should also be noted that even low duty cycle DSA interference may cause highly destructive interference to Project 25 communications, should it impact message headers or other critical information. Similarly, channel vacate times for DSA equipment need to be extremely short (especially for weak LMR signals), since critical synchronization information is contained at the start of LMR transmissions. LMR transmissions are also often unpredictable, and completely asynchronous to other systems. As correctly pointed out in the NTIA testing documents, a typical Project 25 user may not even be aware that a critical message has been lost (or muted) due to interference.

While testing in faded mobile environments is important, it is also important to test in the static (non-faded) noise limited environments mentioned above. Typical required Project 25 reference sensitivity SNR levels are approximately 8dB CNR for these environments (or roughly 8-10dB lower than the mobile faded environments). The full impact on DSA operations on Project 25 data transmissions, in addition to voice calls, should also be assessed for a more complete picture.

IV. Geo-Location Database

Motorola has long supported the use of geo-location databases for spectral sharing, as is required for the secondary use of TV white spaces. Geo-location databases are typically well suited for fixed incumbent systems (as in the TV bands). MSI believes that the NTIA should consider the integration of a geo-location database solution into its test bed, as one possible component of a comprehensive spectrum sharing solution. Note that there are still challenges present in attempting to protect highly mobile incumbent communications systems from interference with geo-location databases. Of particular concern is protecting direct-mode communications (and especially mission critical direct-mode communications), which can occur without notice outside of normal LMR operating areas.

V. Conclusion

Since the Phase II testing as described is quite limited (e.g., to very specific outdoor environments, with voice only transmissions between a LMR base site and mobile, with stationary LMR transmitters and receivers, and limited co-channel interference testing only, etc.), it is unlikely that the Phase II test results will be sufficient to make any wide ranging conclusions. It should also be noted that even if the LMR units are stationary, the interference environment may be non-stationary (due to moving reflectors and other time-varying interference effects), which may make gathering consistent results more difficult.

While Phase III testing attempts to address some of the issues that have been raised here, at least to a limited extent, the combined effects of the real-world issues discussed above are not comprehensively addressed in a highly-controlled manner. Therefore, we believe further testing and development will be necessary, to fully address the concerns detailed in our comments. However, Motorola Solutions commends the NTIA for taking these initial field and lab testing steps, and again thanks the NTIA for the opportunity to provide these inputs on the Phase II and Phase III test-bed plans.