Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the matter of	)	
	)	
Facilitating Opportunities for Flexible,	)	ET Docket No. 03-108
Efficient, and Reliable Spectrum Use	)	
Employing Cognitive Radio Technologies	)	

COMMENTS OF MOTOROLA, INC.

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EXECUTIVE SUMMARY

Motorola believes there are benefits associated with cognitive radio that should be explored. However, the technology is still under development and there are many questions regarding implementation that must be answered before it can be implemented effectively. The protection of existing services, particularly public safety communications, must be a priority in considering the introduction of this new technological approach. In addition, the Commission should not view cognitive radio as a panacea to the problem of spectrum scarcity that can replace sound spectrum management. Rather, it is should be treated as another arrow in the Commission's regulatory quiver used to maximize the efficient use of spectrum, consistent with operational requirements.

Furthermore, Motorola supports the development of software-defined radio ("SDR") policies and guidelines. Such guidelines should be intended to facilitate the development of SDR and should not impede the flexibility of manufacturers to develop new technology or increase the cost or cycle time of equipment certification. Ensuring that rules for SDR provide for the efficient manufacture and deployment of equipment will benefit the public by minimizing costs and delay.

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COMMENTS OF MOTOROLA, INC.

Motorola, Inc. ("Motorola") respectfully submits these comments in response to the Federal Communications Commission's ("FCC" or "Commission") *Notice of Proposed Rulemaking* ("*NPRM*") in the above captioned proceeding intended to develop a regulatory regime for cognitive radio technologies.[1] Motorola believes there are benefits associated with cognitive radio that should be explored. However, the technology is still under development and there are many questions regarding implementation that must be answered before it can be implemented effectively. The protection of existing services, including public safety communications and other licensed services must be a priority in considering the introduction of this new technological approach. Further, the Commission should not view cognitive radio as a replacement for sound spectrum management. Rather, it is yet another tool to maximize the efficient use of spectrum, consistent with operational requirements. In addition, Motorola supports the development of software-defined radio ("SDR") policies and guidelines. Such

[1] Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies, *Notice of Proposed Rulemaking*, FCC 03-322 (Dec. 30, 2003) ("*NPRM*").

guidelines should be intended to facilitate the development of SDR and should not impede the flexibility of manufacturers to develop new technology or increase the cost or cycle time of equipment certification. Ensuring that rules for SDR provide for the efficient manufacture and deployment of equipment will benefit the public by minimizing costs and delay.

I. COGNITIVE RADIO TECHNOLOGY, IF IMPLEMENTED PROPERLY, COULD HAVE MANY IMPORTANT BENEFITS.

A. Background

For over ten years, radio manufacturers have incorporated software-programming capabilities into commercial radios to make it easier to change basic functionality. Specifically, manufacturers have embedded microprocessors and software in radios to control operating parameters, including frequency and modulation type. However, until relatively recently, the software settings installed during manufacturing generally have not been readily adjustable after the radio leaves the factory and enters the field. The ability to alter software settings has come with the emergence of SDR, which allows the radio to be programmed to transmit and receive on a variety of frequencies and/or to use one or more different transmission formats.

Similar to a SDR, a cognitive radio ("CR") may alter its transmitter parameters after manufacturing. However, CR distinguishes itself from SDR[2] by altering its transmitter parameters based on observation of and interaction with the environment in which it operates. The general operating method for a cognitive radio is to detect "other signals"[3] and (1) move to another band; or (2) change transmitter parameters (modulation or other) to coexist with other users. These two modes of operation may be called "avoidance" and "coexistence," respectively. As explained below, this "cognitive" ability to comprehend factors in the surrounding

[2] While most cognitive radios will be SDRs, having software and being field-programmable are not prerequisites for being a cognitive radio.

[3] Either actual traffic or command and control signals (e.g., "beacons")

environment and respond accordingly gives cognitive radio the potential to radically redefine the concept of spectrum access, making it a transformative technology. At the same time, however, cognitive radio must be implemented as part of an overall spectrum management scheme that will ensure that it is not disruptive to primary users.

Radios with some subset of cognitive features are already being deployed. Modern trunked radio public safety systems, such as those built to the current APCO Project 25 standard, employ many of these capabilities (e.g., frequency agility, adaptive modulation, power control, location dependence, the ability to share based on an agreement and security features to control use). All of these features are designed to be controlled within the system by qualified personnel and within the system's authorized parameters. Many Commercial Mobile Radio Services ("CMRS") also already employ some cognitive capabilities in their systems; EDGE and WCDMA (e.g. HSDPA) adapt their modulation and coding based on environmental characteristics, GSM/EDGE technology makes dynamic frequency channel allocations based on the environment, and both CDMA and TDMA systems adjust their base and mobile station power levels. Again, the cognitive elements occur within the licensee's authorized frequencies and operational area. In the unlicensed space, early stage cognitive radio development can be found with devices complying with the Commission's rules in the 5 GHz band.[4] As a condition of operating in this spectrum, manufacturers are required to utilize cognitive techniques such as dynamic frequency selection ("DFS") and transmit power control ("TPC") to protect the primary Federal government licensees.

B. Potential Benefits of Cognitive Radio

Cognitive radio's continued development and deployment has the potential to make it an

[4] Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) devices in the 5 GHz band, 31 CR 54 (Nov. 18, 2003).

important tool, when carefully applied to specific frequency bands and systems, for accessing otherwise unavailable spectrum. The Spectrum Policy Task Force ("SPTF") notes that, "spectrum access is a more significant problem [in many bands] than physical scarcity of spectrum, in large part due to legacy command-and-control regulation that limits the ability of potential spectrum users to obtain such access."[5] Indeed, while some spectrum is intensively used, other spectrum has highly variable use when viewed in terms of time and geography.[6] This may result in inefficient use of the spectrum. By leveraging its ability to engage in "avoidance" and "coexistence," a cognitive radio could possess one or more of several capabilities that would allow it to access spectrum going otherwise unused at a certain time or in a certain area. It would, however, be beneficial for the Commission to quantify these benefits more clearly. In most cases spectrum requirements are driven by peak demand times in densely populated markets. It is not clear how much additional capacity cognitive radio will provide during those peak demand periods and in those locations, and it is not clear how intense the demand for spectrum is outside of those peak periods and locations.

One efficiency-enhancing capability would be frequency agility within authorized parameters – the ability to change operating frequency and dynamically select the appropriate frequency based on the sensing of signals from other transmitters (again, either traffic or control signals/beacons). With this capability, a cognitive radio could search out and find underutilized frequencies, expanding use of the spectrum resource. Another capability, adaptive modulation,

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[5] Spectrum Policy Task Force Report, ET Dkt. No. 02-135, at 3 (Nov. 15, 2002) ("*Task Force Report*").

[6] FCC Cognitive Radio Workshop, "Spectrum Policy and Technology: Spectrum Access and the Promise of Cognitive Radio Technology," PowerPoint Presentation by Lauren Van Wazer, at 5 (May 19, 2003).

would allow a cognitive radio to modify transmission characteristics and waveforms to avoid or coexist with other signals utilizing the same spectrum resource. For example, through adaptive modulation a cognitive radio could permit interoperability among systems by switching between different channel access schemes such as TDMA and CDMA. A third capability, TPC, would allow a radio to adapt power levels based on specific conditions such as the proximity of other devices or geographic power restriction. By making power output more responsive to actual link quality requirements, TPC would foster greater sharing of spectrum. Fourth, the ability to determine its location, and in some cases the location of primary transmitters,[7] is a feature that, when combined with cognitive radio's other capabilities, could allow a cognitive radio device to find and exploit underutilized spectrum. Finally, as recognized in the Commission's Secondary Markets Proceeding, spectrum leasing capability – the ability of a licensee to share spectrum with a third party under the terms of an agreement – may hold opportunities for spectrum to be used at times and in locations where it would otherwise lay fallow or underutilized. This can already be accomplished in prearranged agreements without the need for cognitive radios, but cognitive radio technology may provide an additional technical tool that could facilitate lease agreements among authorized users in some situations.

C. Challenges Facing Effective Implementation of Cognitive Radio

While cognitive radio may greatly increase the efficient use of the spectrum, the technology is still under development and the totality of its impact is unclear. While presenting many possibilities for maximizing use of the spectrum resource, cognitive radio also raises many questions that must be answered before it can be implemented effectively. Indeed, if improperly implemented, cognitive radio could have many harmful effects on various radio operations.

[7] An example of this would be a CR operating in TV spectrum that knows its location and also has access to the service contours of all TV transmitters in the area.

Consequently, it is imperative that cognitive radio not serve as a replacement for, but rather an element within, an appropriate spectrum management regime.

One of the most consequential questions relates to the possibility of cognitive radio creating interference to the operations of existing licensees. The Commission must be able to ensure that, as cognitive radio devices assess the conditions in their environment and adjust their transmitting parameters accordingly to utilize available spectrum, those assessments and adjustments are accurate. Exhaustive testing of CRs under numerous scenarios would be required to validate the non-interference claims, as is currently being done with the devices to access the new unlicensed 5 GHz bands. The cognitive radio must be predictable in how it reacts to multiple situations it would encounter in the spectrum environment.

To neutralize such threats to effective radio operations, the Commission must not view cognitive radio as a panacea to the problem of spectrum scarcity. Instead, the Commission should view cognitive radio as one element in a wireless landscape that must remain subject to clear and effective spectrum management.

II. POLICIES FOR COGNITIVE RADIO DEPLOYMENT SHOULD BE ASSESSED IN A BROADER ANALYTICAL FRAMEWORK, BUT RULES FOR ACTUAL DEPLOYMENT MUST BE ASSESSED AND DEFINED ON A BAND-BY-BAND, SERVICE-BY-SERVICE BASIS

In determining whether it is practical to implement cognitive radio in any specific frequency band, it will be necessary to assess the situation on a band-specific basis because the viability and appropriate mechanisms for operation will vary on a band-by-band and service-by-service basis. It is not feasible to define criteria for cognitive radio broadly across all bands and services. However, it is helpful to look broadly at three scenarios based on the relative regulatory priorities of the services under consideration. These are: (1) unlicensed cognitive radios operating in unlicensed bands; (2) unlicensed cognitive radios operating in licensed bands;

and (3) licensed cognitive radios operating in licensed bands.[8]

A. Unlicensed Cognitive Radios in Unlicensed Bands.

Deployment of unlicensed cognitive devices in unlicensed bands is one of the most appropriate means by which cognitive radio technology could be implemented under the Commission's spectrum management framework. By "unlicensed bands," Motorola means those bands utilized predominantly by unlicensed intentional radiators. Unlicensed devices do not enjoy any protection from interference and must not interfere with devices of higher regulatory priority. In general, the power permitted for devices operating on an unlicensed basis is limited to avoid interference with other devices. It may be possible to permit cognitive radios to operate with higher power in these bands, however, such operation should only be permitted if there is reasonable assurance that these higher power devices would not cause excessive interference to other unlicensed devices and thereby disrupt the general operating characteristics of the band. Accordingly, sensing parameters and maximum transmitting power levels must be delineated appropriately to ensure proper coordination and avoid interference.

The Commission proposes in the NPRM that cognitive unlicensed devices in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5875 MHz ISM bands be permitted to operate with up to 6 times greater power than the rules permit for non-cognitive devices.[9] While the Commission's proposal is appropriate, Motorola believes that additional study is required to quantify the potential impact such operation would have on other devices operating in the bands. As an initial matter, Motorola believes that the Commission's proposal to define "unused spectrum" as

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[8] For completeness, a fourth scenario exits, that of licensed cognitive radios operating in unlicensed bands. We do not consider this as a viable option due to the fact that a licensed radio is not required to provide protection to unlicensed devices.

[9] *NPRM*, ¶36.

spectrum with a measured aggregate noise plus interference power no greater than 30 dB above the calculated thermal noise floor within a measurement bandwidth of 1.25 MHz threshold[10] does not have a substantive basis and requires further study to determine whether the impact on other devices operating in the band is acceptable.[11]

In addition, the benefits of permitting increased power for cognitive devices are not clear. Devices operating in accordance with the Commission's proposal would be required to reduce power if other devices started to operate in the vicinity of the cognitive device. This power reduction could result in loss of service or a reduction in the quality of the higher power link. This results in a very uncertain operating environment and is seems unlikely that a significant number of devices would be deployed under such a scenario.

B. Unlicensed, or Non-Voluntary Sharing, Cognitive Radios in Licensed Bands.

While Motorola recognizes the potential merits of permitting unlicensed cognitive radios to operate in licensed bands, more evaluation must be performed before any implementation in a licensed band should be permitted. Considerable technical obstacles must be overcome before the Commission should allow a cognitive radio to decide when, where, and how it will operate based on its sensing of other radio transmissions in the environment. These obstacles will be

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[10] *NPRM*, ¶44.

[11] As an example consider three unlicensed units arranged in a triangle with equal path loss between all units. The two units at the vertices defining the bottom leg of the triangle transmit 1 W, and experience 102 dB path loss, so that the desired signal power level is -72 dBm over 20 MHz (which corresponds to a density that is 29 dB above thermal). The receivers are assumed to have 10 dB noise figure, so there is still 19 dB C/I, sufficient for acceptable communications at reasonable bit rates. Now a cognitive unit sitting at the upper vertex of the triangle senses communications from both units and finds that they are less than 30 dB above thermal (they are only 29 dB above). It decides it can then commence transmission at 6 W, or +38 dBm. With the assumed 102 dB path loss, the transmissions arrives at both receivers at -64 dBm, and the receivers which were previously enjoying 19 dB C/I are now subjected to -8 dB C/I. Clearly this is not a fair representation of vacant spectrum, and more studies are needed to determine adequate detection thresholds to properly assess total spectrum occupancy and protect other unlicensed operations.

considerably less in some bands and services than in others. However, an overriding priority in considering any unlicensed use of licensed spectrum must be the need to protect the existing and primary services. Accordingly, a careful band and service-specific analysis must be undertaken prior to allowing unlicensed use of licensed bands.

1. Certain Bands and Services Present Unique Challenges and Should Not be Considered For Unlicensed Cognitive Radios

There are certain licensed bands and services that present unique challenges and which are not appropriate to consider for use by unlicensed cognitive devices. These include frequency bands used for mobile services, including the commercial mobile radio service, and frequency bands used for public safety services. In addition to implementation challenges, there are significant concerns about being able to take enforcement measures against devices deployed on an unlicensed basis. Once an interference problem occurs, it will be difficult or impossible to locate the unlicensed device or to remove a large number of devices once they are deployed.

Mobile services present the most challenging environment for implementing cognitive radios in a way that does not present an interference threat to the licensed service. The mobility of service users in mobile bands makes it impossible for current generation cognitive radio technology to model accurately the interference environment on a dynamic basis.[12] In addition, certain technologies operating in CMRS bands require significant bandwidth, particularly those that are designed to provide data services. Bandwidth incompatibilities between cognitive radios and target devices can prevent cognitive radio devices from detecting those other devices. Consequently, it is not appropriate to consider bands used for CMRS for non-voluntary use by

[12] Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile, and Satellite Frequency Bands, ET Dkt. No. 03-237, Comments of Motorola, 7 (Apr. 5, 2004) (*Motorola Interference Temperature Comments*).

cognitive radio devices.

In the case of public safety or other critical communications, the above-mentioned uncertainty of implementing the frequency-sensing element of cognitive radio "is exacerbated in [such] bands ... where the criticality of communications justifies providing the highest levels of protection."[13] While the Commission has made proposals in an attempt to provide access to frequency bands used by public safety, the Commission should not undermine the reliability of mission critical communications in current or additional future frequency bands used for public safety and critical infrastructure entities by trying unproven methods of spectrum sharing.

2. Challenges of Cognitive Radios Accessing Licensed Bands

As Motorola established in its comments filed in the Commission's *Interference Temperature Proceeding*,[14] a host of challenges such as antenna shadowing, path loss uncertainty, varying antenna patterns, varying levels of detector sensitivity, and incompatible transmission formats, all combine to make it impossible to predict whether measurements accurately reflect radio activity in a given radio environment. If they are not accurate and predictable, primary users of the spectrum will likely encounter interference affecting service that they had relied upon the Commission's current interference protections to prevent.

This obstacle is perhaps best illustrated by the difficulties involved in applying a DFS technique to different systems. In its *Interference Temperature Comments*, Motorola demonstrated that the application of DFS parameters designed to protect high power radars in the 5 GHz band will result in significantly different outcomes when applied to systems in the 6525-

[13] *Id.*, 6.

[14] *Id.*, 11-13.

6700 MHz band.[15] Specifically, when applying the same DFS parameters in the 6 GHz band, the interference experienced by operators was more than 60 dB higher than the interference experienced by operators in the 5 GHz band. This difference shows that, because the characteristics of bands and licensees differ, "the positive results from use in one band cannot be used as a basis for establishing an interference temperature level in the other."[16]

Motorola does recognize that there may be other techniques for sensing the radio environment that may be more readily applied than DFS. For example, some sort of geo-location requirements linked to defined zones where operation will not cause interference may be a possibility. Specific examples might include "white zones" between broadcast coverage areas where spectrum is unused and downlink satellite bands where all earth terminals are registered.[17]

Among the most notable challenges that will confront an unlicensed CR accessing licensed bands are 1) the difficulty in detecting and properly classifying the transmissions of the primary user, 2) the difficulty in predicting and responding to future channel activity by primary users, 3) the difficulty in determining the incumbent's receiver locations, and in estimating path loss and contributions from itself and other interferers at the primary receivers. Each of these will be considered by means of an example that demonstrates the challenges that need to be overcome.

Difficulty in detection of the primary user may be due to unfavorable propagation conditions between the primary user and a CR. An obvious example would be excess

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[15] *Id.*, 12-13.

[16] *Id.*, 13.

[17] FCC Cognitive Radio Workshop, "Frequency Agile Spectrum Access Technologies," PowerPoint Presentation by Mark McHenry, at 22 (May 19, 2003).

attenuation due to shadowing or barrier penetration (e.g. into a building). For some modulations, the use of feature detectors[18] can mitigate this problem. However, some modulations such as CDMA can still be a problem, sometimes operating at C/I levels well below 0 dB at the primary receiver. The signal could be even weaker at the CR receiver. In such cases, feature detectors with long integration times can be required. If the messages are short, bursty packets, the integration becomes more complicated. In any case, the long integration times become problematic in the detection of primary user activity for the purpose of evacuating a channel, as discussed below.

For non-continuous[19] transmissions, it will be very difficult if not impossible for the CR to predict when primary user activity will be initiated or resume on the channel. For example, in a trunked system, a traffic channel is idle until it is assigned to a talk group. It may be possible to compile statistics on the time between assignments and predict to a certain confidence when the primary user will be accessing the channel, but the statistics would not necessarily be stationary and even if they were, there are still bound to be cases where the prediction fails miserably. The same would hold for packet communications and TDMA systems where new slots are assigned in unpredictable ways. The consequences of non-voluntary third parties lingering on a resource when the primary user needs it could be significant and should not be casually dismissed. In a public safety setting, a fraction of a second is all an officer needs to take cover in a hostile situation; if an alert instructing him to do so by a fellow officer is delayed due to slow resource release by a non-voluntary user, the cost is incalculable.

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[18] *NPRM*, ¶25.

[19] A TV broadcast would be an example of a continuous transmission. Even if a channel is not on 24 hours a day, its transmissions will generally be predictable, such as a channel going off the air at 2:00 AM and returning at 6:00 AM.

A CR's knowledge of its location may be helpful in a well-defined, static environment, but it doesn't help if the CR doesn't know the location of the nearest primary receivers as well as the propagation conditions to each receiver. At some point, most primary systems will have a transmission on some frequency originating from the receive site. A notable exception to this is broadcast services, such as television. But even if the primary unit does have a transmitter, the CR doesn't necessarily know the transmit power of the unit, so it cannot gauge path loss between the two units. This is especially so if the primary transmitter is using power control to compensate a dynamically varying path loss between two primary units. Since the path loss between the primary unit and the CR will be different, the net effect is a dynamically varying transmit power added to an uncorrelated (to the power control) varying channel, exacerbating the variance of the power received at the CR and degrading the estimator. Another example would be if the primary unit was an element in a cooperative relay with directional antennas. The direction of arrival and direction of departure are dynamically determined by the mesh configuration and traffic path, so that the receive antenna pattern may differ substantially from the transmit antenna pattern. There may be very little transmit power in the CR's direction, even though the receiver may be looking directly at the CR.

Lack of certainty in range or path loss to a primary receiver means that the CR cannot estimate the interference level it may cause at the victim receiver. As an additional complication, the CR cannot know if other non-voluntary CRs are also transmitting from other locations and contributing additional interference at the victim receiver that is undetectable at the CR unit in question because the primary signal level obscures it.

Even if a CR successfully monitors a channel and determines that it is vacant, operation on an adjacent or alternate channel or some image frequency can still degrade communications for the primary user. Most mobile radios have reasonable selectivity at the adjacent channel, but there are limits. The CR must know and respect what these limitations are, as well as the transmit mask, transmitter noise floor, frequency stability, and even edge transients, for whatever primary system it wanders into.

C. <u>Licensed, or Voluntary Sharing, Cognitive Radios in Licensed Bands.</u>

Cognitive radio in licensed bands through voluntary agreements may provide benefits for efficient use of the spectrum and allows the primary licensee to control the cognitive radios use of and access to spectrum. This scenario essentially implements the principles of secondary market licensing and the "spectrum manager" approach to spectrum leasing envisioned by the Commission.[20] However, to remain consistent with those principles, the licensee of a band being leased, via a licensed cognitive radio device, must retain the ability to address and control the interference that it may receive. Licensed users must not be unduly interrupted under this framework. Also in keeping with the principles of limiting regulatory uncertainty and intervention embodied in the Commission's secondary market policy,[21] the technical details on how to implement spectrum leasing should be left to the licensees and their lessees to reconcile. Licensees own self-interest in ensuring their ability to use their spectrum will foster adequate pre-designated conditions. This approach avoids the Commission having to adopt individual technical guidelines for myriad technical scenarios that could arise under spectrum leasing arrangements between licensees and lessees each employing different technologies or transmitting parameters.

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[20] See *NPRM*, ¶¶53-55.

[21] Promoting Efficient Use of the Spectrum Through Elimination of Barriers to the Development of Secondary Markets; Report and Order and Further Notice of Proposed Rulemaking, *Report and Order and Further Notice of Proposed Rulemaking*, WT Docket No. 00-230 (May 15, 2003).

The Commission also seeks ways to facilitate automated frequency coordination among licensees of co-primary services. Motorola supports such cognitive radio-based automated coordination, provided such coordination is done voluntarily between the licensees. As in the previously discussed scenarios, the licensees own self-interests will foster the necessary protections and safeguards for each co-primary service.

While Motorola generally supports the concept of licensed cognitive devices operating in licensed bands under secondary market arrangements, it opposes the Commission's proposal to utilize beacons as an access/reversion mechanism for interruptible leasing of public safety spectrum.[22] While the Commission's proposal attempts to provide a fail safe mechanism by proposing that cognitive radios only transmit when they can receive a beacon, Motorola believes that, because of the critical nature of public safety communications, it is inappropriate to experiment with untested sharing procedures in spectrum used for public safety communications.

III. THE COMMISSION'S OTHER PROPOSALS FOR COGNITIVE RADIO USES SHOULD BE EXPLORED.

A. Motorola Urges the Commission to Make More Spectrum Available to Facilitate Public Safety Interoperability

In the *NPRM*, the Commission describes potential benefits that cognitive radio devices could provide for public safety and homeland security officials by dynamically changing the radio characteristics to allow for greater interoperability between users.[23] This is a very different scenario than using cognitive devices to allow spectrum to be shared amongst multiple and potentially incompatible users and may represent a new tool for first responders and other public safety personnel to use in reducing risks to safety of life and national security. Motorola

[22] *NPRM*, ¶¶57-59, 62.

[23] *Id.*, 76.

notes that multi-band, multi-mode radios exist and are used today. Regardless of whether interoperability is achieved using a multi-mode, multi-band radio, or a cognitive radio with even more advanced features, the critical elements in effective communications will be standardized systems, personnel that are trained in their use, and planning to provide effective communications.

The vast majority of public safety communications pertains to the day-to-day activities of first responders within their local jurisdictions, and meeting these requirements must come first and foremost. However, a number of events require improved interoperability among agencies within a given jurisdiction, among different jurisdictions, and even among state/local jurisdictions and Federal agencies. Such interoperability among state and local first responders and federal agencies will best be achieved through planning, use of common industry-developed standards, and the availability of comparable spectrum resources. For example the P25 interoperability standard has been developed and supported by a partnership of local and state public safety agencies, Federal entities, and industry. Multiple manufacturers build equipment to this standard. While much progress has been made in the area of standards, additional work is needed in the areas of ensuring spectrum availability and planning.

The Commission noted in the *NPRM*, that communications between entities responding to the attack on the Pentagon on September 11, 2001 were not as effective because operation in other bands had not provided the foundation for planning and prior coordination was not conducted among the various entities.[24] However, this problem occurred primarily between local/state and Federal entities that do not have sufficient spectrum resources in the same or nearby bands. In contrast, multiple local agencies operating within the 800 MHz band that had

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[24] *Id.*, ¶¶74-76.

compatible technology and had established incident response operational procedures through planning and practice communicated very effectively with one another during the response to the Pentagon attack.

As a result, we have learned that greater emphasis should be placed on providing sufficient compatible spectrum and overall coordination and planning among all potential responders. Doing so will ensure that they have the foundation and equipment necessary to achieve interoperability among the various communications networks used in day-to-day activities, and that they are prepared to respond in a coordinated manner.

As noted, one key aspect of achieving interoperability among the various jurisdictions is that state, local, and Federal responders have access to comparable and adequate spectrum resources. Such resources are not available today. In 1997, however, Congress mandated that 24 MHz of spectrum in the 700 MHz band be made available for public safety at the state and local level. This spectrum will provide additional voice capacity, and will also accommodate a new generation of advanced wideband communications providing first responders video and data services that will greatly enhance their effectiveness and safety once television is cleared from the band. However, nearly seven years later, there is still no certainty as to when this much-needed spectrum will be available in most major urban areas due to the slow pace of the digital television transition. The Commission should act aggressively to ensure that this spectrum is made available for public safety as early as possible. Additional spectrum at 700 MHz beyond the 24 MHz originally allocated for state and local also should be considered for Federal, state, local and critical infrastructure use.

B. <u>Mesh Networks</u>

The NPRM also sought comment on the application of mesh network technology and possible rule changes needed to facilitate the use of the technology.[25] Motorola believes that mesh network technology can enhance spectral efficiency by utilizing a peer-to-peer relaying process that requires lower transmitter power to complete a transmission. As this promising technology continues to develop, it is important that it not be saddled with unnecessary or overly burdensome rules. Motorola believes that existing rules for unlicensed devices are sufficient to facilitate the development of mesh network technology in a manner that also will prevent harmful interference.

IV. THE COMMISSION'S TESTING AND EQUIPMENT AUTHORIZATION PROCESSES SHOULD BE MODIFIED TO ACCOMMODATE COGNITIVE RADIOS.

Motorola agrees with the Commission that because cognitive radio can perform functions not envisioned when the current rules were developed, it is now appropriate to modify certain rules to accommodate this emerging technology. Specifically, Motorola supports certain proposed modifications to Part 2 of the Commission's rules addressing software-defined radio, as well as the Commission's pre-certification testing requirements. Motorola believes that these modifications will enable manufacturers to design, produce and market the type of cognitive radio devices capable of increasing spectral efficiency, while also ensuring that the equipment remains safe, efficient, and unlikely to cause harmful interference.

A. Changes to Part 2 of the Commission's Rules

1. Applicability of SDR Rules

In the *NPRM*, the Commission asked whether manufacturers and/or importers must be

[25] *Id.*, ¶77.

required to declare a cognitive radio to be an SDR.[26] Once declared an SDR, the device must include security features that ensure that only software that is part of an approved hardware/software combination can be loaded. Motorola opposes any rule requiring it to declare whether a device constitutes an SDR. Despite the Commission's *NPRM* request for comments on what types of devices qualify as an SDR, the definition of SDR is still too broad to ensure that certain devices are not improperly included. Indeed, as SDR and cognitive radio technology continue to develop, the definition of SDR is sure to only become less precise. As a result, the Commission should avoid imposing a requirement that could improperly restrain certain technologies and, in turn, their development.

2. Submission of Radio Software

The Commission also proposed that it delete its current requirement that manufacturers of SDRs provide the Commission a copy of the software source code that controls the device's frequency operating parameters and replace it with a less burdensome requirement that manufacturers provide the Commission with a description and flow diagram of the software. Motorola supports adoption of this proposal. Motorola agrees with the Commission that receiving actual software would not prevent unauthorized changes because source code is compiled before loading and additional changes could be made after the loading process. Moreover, the existing requirement is superfluous. As the Commission has noted, existing requirements in the rules that require certified equipment to comply with applicable technical rules and obligate manufacturers to produce sample devices and records upon Commission request already provide sufficient safeguards against unauthorized changes to equipment.[27] However, Motorola urges the Commission to clarify exactly what information should be

[26] *NPRM*, ¶88.
[27] *Id.*, ¶86.

provided in this new submission and to what level of detail the software must be described. In doing so, Motorola also asks that the Commission keep in mind the highly proprietary nature of software information and the real competitive harm that could be caused to a manufacturer if that manufacturer's competitors were to access it. Indeed, in defining exactly what software information manufacturers must produce, the Commission also should designate that information as non-public and grant it full confidential treatment under Commission rules.

3. Security and authentication requirements

Motorola opposes the adoption of any rule changes that would incorporate explicit security requirements, such as requiring electronic signatures in software, to prevent unauthorized modifications to SDRs.[28] Rather, Motorola believes a standards-based approach for security, incorporating industry practices, will adequately guard against unauthorized changes to SDR software and will provide industry the ability to update security measures as they become available without seeking Commission action. While a standards-based approach will provide the effective approach to security, it is always possible for even the best security measures to be bypassed. A manufacturer should not be held responsible for variations from those standards that are outside of the control of the manufacturer – *i.e.*, changes to software made by a party other than the manufacturer and after it left the manufacturer's control.

B. <u>Pre-certification Testing Requirements for Cognitive Radios</u>

As noted above, changes to the Commission's pre-certification testing requirements are appropriate to accommodate the previously unconsidered functionality of cognitive radios. In its *NPRM*, the Commission requested comment on whether new types of certification tests should be developed for both unlicensed and licensed transmitters. Motorola agrees that new tests are

[28] *Id.*, ¶¶93-94.

appropriate. As the Commission stated, because of cognitive radios' adaptability, their output must be tested in response to various inputs and/or combinations of inputs.[29] However, Motorola recommends that these new tests be developed through the industry standards organization, the American National Standards Institute (ANSI). Tasking ANSI with developing these rules would place the job in the hands of an entity possessing both the requisite expertise and objectivity.

V. CONCLUSION

Cognitive radio can be a valuable tool for improving the utilization of spectrum. There are, however, numerous questions with implementation of this technology and it is necessary for the Commission to further analyze the impact that the introduction of cognitive radio technology will have on existing services prior to modifying rules to allow its use.

Respectfully submitted,

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[29] *Id.*, ¶100.