Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Request for Waiver of Measurement	)	ET Docket No. 04-352
Procedures for OFDM Ultrawideband Devices	)	

REPLY TO OPPOSITIONS

The Multi-band OFDM Alliance Special Interest Group (MBOA-SIG)[1] through its counsel, hereby replies to the oppositions filed in the above-referenced proceeding. MBOA- SIG has requested a waiver of the Commission's frequency hopping measurement procedures and the "pulse gating" rule in Section 15.521(d), to allow MB-OFDM ultra-wideband (UWB) systems to be tested for average emissions under normal operating conditions, rather than with band sequencing stopped. Many parties support the waiver request.[2] Opponents contend that a waiver is likely to result in harmful interference to other spectrum users and give MB-OFDM manufacturers a competitive advantage in the emerging UWB market. As the following comments will demonstrate, neither concern is even remotely justified.

Background and Introduction

In its Petition, MBOA-SIG referenced extensive test data demonstrating that MB-OFDM systems, tested under normal operating conditions, pose no greater threat

[1] The MBOA-SIG is a collection of large and small entities led by a group of MB-OFDM "promoters" including Intel, Texas Instruments, Staccato Communications, Alereon, Wisair, Sony, Philips, Nokia, Panasonic, Samsung, Hewlett Packard, Microsoft and ST Microelectronics. Virtually all segments of the electronics industry are represented in the MBOA-SIG, including: 9 of the top 10 semiconductor companies; all of the leading consumer electronics companies; all of the Wireless USB Promoter Group's companies; 10 of the 16 IEEE 1394 Trade Association Director Companies; and 10 of the 11 WiMedia Promoters. Alereon, Artimi, Staccato Communications, TZero Technologies and Wisair, all leading startup companies, are members of the MBOA-SIG and have collectively received venture capital funding in excess of $125M for the development of MB-OFDM solutions.

[2] See comments of Phillips Electronics North America Corporation; WiMedia Alliance; Renasas Technology American, Inc.; Time Domain Corp.; FOCUS Enhancements, Inc.; Cetecom, S.A.; Hewlett-Packard Company; and WiLinx Corporation.

of harmful interference than pulsed UWB systems permitted by the rules. MBOA-SIG showed that the procedures requiring frequency hopping to be stopped[3] and/or pulse gating to be applied are not properly applicable to MB-OFDM systems, were never intended to apply to MB-OFDM and their application to such systems would unfairly burden this new technology.[4] In response, several parties attempt to show that MBOA-SIG's technical studies and data are flawed; that MB-OFDM systems will, in fact, interfere with C-band satellite systems and with other unlicensed devices; and that a grant of the waiver will give MB-OFDM an unfair competitive advantage in the UWB marketplace.[5] None of these arguments has merit.

Sound engineering analysis has repeatedly demonstrated that the MB-OFDM waveform, tested under normal operating conditions, is less likely to cause interference to spectrum users than other compliant UWB technologies. Indeed, MB-OFDM, more than any other UWB modulation scheme, has inherent spectral shaping capabilities to mitigate unforeseen interference situations. As the comments filed in this proceeding clearly show, the waiver will simply than level the UWB "playing field" and permit consumers, rather than Commission rules, to decide which UWB technology best serves the public interest.

I. Claims of Increased Harm to C-band Satellite Systems and Other UWB Devices are Groundless.

Freescale and others opposing the Petition maintain that the requested waiver would give MB-OFDM systems a 5 to 6 dB advantage over direct sequence and

---

[3] With hopping "stopped" the signal in any band is made to transmit continuously rather than periodically as is the case during normal operations. This procedure creates artificially high emissions levels that do not reflect how MB-OFDM devices actually operate.

[4] No party disputes the fact that the Commission's "stop hopping" test procedures derive from the spread spectrum rules and were never contemplated to apply to band-sequenced UWB systems. In addition, no party has challenged the observation that the express language of the Commission's "gating rule" (i.e. Section 15.521(d)), does not apply to MB-OFDM systems. The MB-OFDM waveform can be characterized as either pulsed or gated but not both. Rule 15.521(d) only applies to pulsed UWB waveforms that are also gated.

[5] Parties opposing the petition include TimeDerivative, Inc.; PulseLink, Inc.; the Satellite Industry Association; the Coalition of C-Band Constituents; Motorola, Inc. and Freescale Semiconductor, Inc. In the case of Motorola and Freescale it should be noted that Freescale is a recent spin-off of Motorola in which Motorola still retains a majority ownership interest. Thus, their comments should be read collectively.

pulsed UWB systems and, therefore, 5 to 6dB of additional interference to C-band satellite systems and other spectrum users.[6] Freescale claims that its own analysis and measurements confirm these allegations. According to Freescale, a three-band MB-OFDM system had to have its average power set 5 dB lower to equal the interference levels of a compliant pulsed UWB device.[7] A careful review of the submitted data, however, shows that Freescale's analysis is misleading and groundless.

At the onset, it must be established that there will be no 5-6 dB "advantage" under the waiver. Freescale's assertions to the contrary merely underscore its fundamental misunderstanding of the UWB rules. The 5-6 dB "increase" in signal power that Freescale complains about is the amount by which the peak emissions exceed the average in each of the three bands in an MB-OFDM device. The difference is due to the pulsed, or duty cycled, nature of the device and represents the different measures of radio interference to victim receivers in the three bands.[8] Because the UWB rules expressly permit duty cycling, they also set both peak <u>and</u> average emission limits to prevent harmful interference to all types of licensed systems.[9] Pulsed UWB waveforms, including Freescale's, generate peak emissions that are above average, and some generate peaks that are even greater than the MB-OFDM peaks about which Freescale is so concerned. As an example, the FCC rules allow a pulsed UWB device to generate peak emissions that are 24.3 dB above average, as measured in a 50 MHz bandwidth,[10] but this does <u>not</u> mean it enjoys a

---

[6] Freescale Comments at 9, Motorola Comments at 8 and TimeDerivative Comments at 3

[7] Id.

[8] A receiver in one band cannot be interfered with by a transmission in another band. MB-OFDM bands are over 500MHz wide and the victim receiver bandwidths are, at most, a magnitude narrower. See *UWB Transmissions Systems,* First Report & Order, ET Docket 98-153,17 FCC Rcd. 7535 at par. 208 (hereinafter UWB FR&O). Thus, it is only logical and accurate for interference measurements to look at MB-OFDM systems on a band by band basis – a feat which cannot be performed with band sequencing stopped.

[9] In the UWB First Report and Order, the Commission made this clear:

> "We agree that burst transmissions would have a low average measurement because of their short period of operation . However, the peak levels we are establishing would limit such transmissions." UWB FR&O par. 241.

[10] This figure comes from Rule 15.521(g) which computes the peak power limit as follows: 20 log10(RBW/50) dBm. With a 50 MHz RBW (resolution bandwidth), the peak limit is 0 dBm, and the average power in a 50 MHz bandwidth is 10 log10(50) – 41.3 dBm = -24.3 dBm. These calculations results in a peak which is 24.3 dB higher than average, as measured in a 50 MHz bandwidth.

24.3 dB "advantage" over other UWB devices. It simply indicates that pulsing schemes create higher peaks for the same average power as permitted by the rules. Thus, it should be readily apparent that Freescale's claims of an advantage for MB-OFDM are misleading or false and demonstrate an apparent misunderstanding of the regulatory scheme adopted by the Commission for various types of UWB technologies.

Freescale, the Satellite Industry Association (SIA) and the Coalition of C-band Constituents also express concern over the interference potential of MB-OFDM devices to C-band receivers.[11] SIA states that it has been led to believe "by a proponent of a competing technology" that MB-OFDM will cause 5-9 dB more interference to fixed satellite systems than DS-UWB.[12] The technical analysis set forth in Attachment A, however, refutes these charges and shows how such comparison is factually incorrect.[13] In addition, Attachment C contains results of simulations, lab measurements and actual field testing taken with C-band receivers and demonstrates conclusively that: (i) MB-OFDM is significantly less interfering than impulse radios allowed by the rules; and (ii) under realistic operating assumptions, the interference power from <u>all</u> UWB waveforms will be well below the "system noise floor"[14] and thus, has negligible impact on C-band satellite systems.[15] What these tests also conclude is that C-band interference is more a function of average interference power than the shape of the particular UWB waveform. Thus,

---

[11] SIA and the C-Band Coalition also raise interference concerns about UWB devices generally. However, the Commission has already found in its UWB rulemaking proceeding that its Part 15 limits are sufficient to protect fixed satellite systems and, therefore, it is not necessary to revisit these issues here.

[12] SIA Comments at 6

[13] See Section 2 in Attachment A which describes realistic I/N ratios to be expected for C-band satellite systems. Section 3 provides simulation, lab measurement, and field measurement results clearly demonstrating that the impact of MB-OFDM waveforms is less that other waveforms allowed by the rules.

[14] The "system noise floor" is comprised of the thermal noise floor and the noise floor from other sources including other satellite systems.

15 As an example, field trials demonstrated that the C-band satellite link had only 2.5 dB of margin available, so it would not be able to tolerate a strong interfering UWB signal no matter what shape the UWB waveform takes. See Section 3.3 and Attachment C for a more complete description of the field measurements.

the industry's concerns about MB-OFDM interference to C-band systems are misplaced.

Data in Attachment A further shows that the MB-OFDM waveform is little different from white Gaussian noise (WGN) in terms of its impact on other unlicensed devices.[16] As a preliminary matter, interference to unlicensed devices is a non-issue as far as the waiver is concerned because such devices must accept interference from other devices.[17] Nonetheless, MBOA-SIG analyzed the impacts of the waveform on Wi-Fi (IEEE 802.11a) and UWB systems to establish that there are no harmful effects. For Wi-Fi devices,[18] the data shows the MB-OFDM waveform to have essentially the same impact on bit error rate (BER) performance and automatic gain control (AGC) operations as background noise. For UWB systems,[19] the data shows almost no difference in the instantaneous interference power from an MB-OFDM and a DS-UWB system operating over the same bandwidth; thus, the impact on "victim" UWB receivers would be essentially the same.[20] In short, Freescale's concerns that the MB-OFDM waveform will interfere with other unlicensed device operations are without merit.

II. The Technical Justification for the Waiver is Correct and Accurate.

The MBOA-SIG Petition provides detailed technical analyses on the interference characteristics of the MB-OFDM waveform in comparison to other UWB waveforms allowed by Commission rules. MBOA-SIG performed bit level simulations, amplitude probability distribution (APD) analysis, lab measurements and field tests in the vicinity of operating C-band receivers. Individually and

---

[16] See Sections 2.2 and 2.3 in Attachment A, which address potential interference into IEEE 802.11a and other UWB devices, respectively.
[17] See Section 15.5(a) of the rules
[18] See Technical Analysis of the MBOA-SIG Petition for Waiver , September 29, 2004, attached to the Freescale Comments (hereinafter "Freescale Technical Analysis") at Section 5.2.
[19] Freescale claims that the noise floor of all other UWB devices would be raised far more by MB-OFDM devices than other classes of UWB devices. Freescale Technical Analysis Section 4.2.2. PulseLink makes similar claims. See PulseLink Comments at 5.
[20] See Section 2.3 in Attachment A which demonstrates that a MB-OFDM waveform and a DS-UWB waveform, for example, would have similar impacts on another UWB receiver occupying the same bandwidth.

collectively, these analyses demonstrated conclusively that the waiver will not cause harmful interference to spectrum users and, moreover, will likely cause less interference than certain pulsed UWB emitters permitted by the rules.

Freescale challenges the MBOA-SIG findings, claiming that the simulations used wrong measures for signal interference and BER; that the APD analysis does not support MBOA-SIG's assertion of comparatively lower interference and, in any event, was done incorrectly; and that the C-band receiver testing erroneously relies on measurements in the near field.[21] Freescale also complains that analytical data was provided only for the "least interfering" of the four MB-OFDM time-frequency codes.

Freescale's objections are baseless.[22] Although they purport to be grounded in Freescale's own, lengthy technical study, they are wildly off the mark. Indeed, they appear to be designed solely to "muddy" the technical record in this proceeding and delay Commission action on the waiver request, thereby preserving Freescale's "first to market" advantage. MBOA-SIG urges the Commission not to be fooled by such self-serving tactics. As discussed further below, the technical materials submitted by MBOA-SIG are correct and accurate, and firmly establish that a waiver will not increase the risk of interference to any licensed or unlicensed service as compared to other UWB waveforms allowed by the rules.

A. System Noise is a Reality and Must be Included in any Comparison of UWB Waveforms.

Freescale claims that "noise floor" should not have been included in the interference term because it "underestimates the interference of MB-OFDM relative

[21] Freescale Comments at 12.

[22] Other commenters also assert that the MBOA-SIG technical analyses are in error but provide no support, other than previously submitted IEEE papers, for such assertions. See e.g., Pulse-Link Comments Section IV, Coalition of C-Band Constituents (Engineering Appendix), Satellite Industry Association Comments at 5 and TimeDerivative Comments at 5. decaWave provides an interference analysis of the MB-OFDM waveform to support its claims that such waveform will create more errors than DS-UWB but this analysis is also in error as discussed in Section 3.4.4 in Attachment A.

to direct sequence and impulsive ultra-wideband."[23] Attachment A explains, in detail, why the "system noise floor" data must be taken into account if UWB device interference is to be accurately measured under "real world" conditions. Freescale's claim that noise floor measurements unfairly skew the interference effects of the MB-OFDM waveform is simply incorrect. The truth is just the opposite: good engineering analysis requires that the system noise floor data be included in order to make comparisons of different waveforms meaningful.[24] This is borne out by MBOA-SIG's field trials which found that the C-band satellite link has only 2.5 dB of available margin and thus, is unable to tolerate a strong interfering UWB signal regardless of the shape of the waveform.[25] For any UWB waveform not to cause harmful interference to such receivers the interference power must be well below the receiver noise floor. Accordingly, any comparison between different UWB waveforms will only be meaningful if all system noise is included.

B. BER Criterion Used in MBOA-SIG Analyses is Correct.

Freescale and TimeDerivative fault MBOA-SIG for selecting an unrealistically high BER in its simulation analysis.[26] Freescale also charges that "the curves and corresponding [MBOA-SIG] conclusions are misleading, and to a skilled communications engineer, they are fatally flawed and have no technical merit."[27] These remarks are grossly exaggerated and false.[28] MBOA-SIG is well aware of the BER requirements for satellite systems and demonstrates, through simulations, laboratory measurements and field tests that quasi-error free performance can be

---

[23] Freescale Comments at 13.

[24] Attachment A Section 2.1 demonstrates that UWB signals meeting the FCC criterion will be well below the system noise floor of the C-band receiver. In this case, even the opposing commenters agree (see more detailed discussion in Section 2.1 and 3.1) that the UWB interference would be masked by the background system noise. Therefore, the proper analysis must include the presence of system noise in order to reflect actual operating conditions.

[25] MBOA-SIG field measurements are discussed in more detail in Attachment A, Section 3.3 and Attachment C.

[26] Freescale Comments at 13; TimeDerivative Comments at 9.

[27] Freescale Technical Analysis at 7.

[28] Section 3.2 in Attachment A describes the correct quasi-error free operating point well-known to the satellite industry and shows that Freescale's complaints about the BER comparisons are simply wrong, and that the recommended uncoded BER operating point, proposed by TimeDerivative, incorrectly accounts for the coding gain.

maintained in the presence of MB-OFDM transmissions.[29] The concerns of Freescale and TimeDerivative are, therefore, wholly unfounded.

C. MBOA-SIG Field Tests are Valid and Reflect Real World Conditions.

Freescale argues that the MBOA field measurements are invalid since they were taken in the near-field of the C-band satellite receiver where, according to Freescale, "results are essentially random" since readings in the near-field can change "by tens of dB over 1/4 wavelength."[30] Freescale also argues that the field tests were conducted by "moving sources around the near field" of the satellite receiver.[31]

A thorough treatment of this issue is provided in Attachment A.[32] Initially, it should be noted that the near field of the 3 meter C-band antenna extends out to approximately 600 feet.[33] To conduct testing in the far field, therefore, the UWB energy would be so far below the noise floor of the receiver as to render testing meaningless. No one argues that the near field is as well behaved as the far field for the prediction of behavior and coupling. It is a very complex region. However, the near-field results cannot be classified as being random since they can be used to provide relevant feedback on C-band satellite disturbance measurements.

Freescale proceeds to mislead the Commission by selectively omitting details of the tests. Freescale argues, for example, that the MBOA field tests were conducted by "moving sources around the near field and side lobes of a C-band satellite dish,"[34] producing erroneous results. What Freescale fails to mention, however, is that MBOA-SIG performed both Same Position Testing and Separation Distance Testing with the C-band receiver and it was the latter test which required "sources" to be moved. For Same Position Testing all transmitters were kept in precisely the same

---

[29] Attachment A in Section 3.2. See also EN 300 421 v1.1.2 (1997-08), Digital Video Broadcasting; Framing Structure, channel coding and modulation for 11/12 GHz satellite services. The same coding method as defined in this specification is used in the Freescale tests and is standard in digital C-band satellite receivers.
[30] Freescale Comments at 14-15.
[31] Id.
[32] Attachment A, Section 3.3. A more complete description of the field measurements is also provided in Attachment C to address any misconceptions about the testing procedures.
[33] Freescale actually argues that the near field extends to 1000 feet. Freescale Comments at 3.
[34] Freescale Comments at 14

locations; thus, under conditions kept constant, very little difference was detected among the UWB waveforms using the same power spectral density (PSD) into the C-band system. For Separation Distance Testing under realistic usage scenarios, the difference among waveforms was also quite comparable (i.e. within a meter).[35] Freescale's claims that MBOA-SIG testing in the near field produced invalid results is simply untrue.

D. MBOA Technical Comparisons Correctly Show that MB-OFDM Waveforms do Not Cause More Harm than Impulse Waveforms.

In its technical appendix, Freescale attempts to show by simulation that the MB-OFDM waveform is more harmful than both direct sequence and pulsed UWB waveforms by 4.5 to 5 dB.[36] These findings, however, do not reflect any realistic scenario because the Freescale simulations presumed a noiseless environment. In addition, Attachment A shows that the Freescale results cannot be correct and that the MBOA-SIG simulations, even in the theoretical noiseless environment, showed an opposite conclusion – namely, that the impulse radio is, in fact, the most harmful interferer. Replication of the Freescale simulations also demonstrate that, even with the noise floor removed, a more modest offset of 2.8 – 3.8 dB between the MB-OFDM waveform and WGN was observed.[37] However, evaluating system performance in the absence of noise is simply an academic exercise and does not reflect actual operating conditions. Simulation results reflecting real-world effects, factoring in noise and realistic clipping levels, as well as previously published lab measurements which also inherently account for real implementation effects are described in Section 3.4 of Attachment A. These results consistently show that MB-OFDM is <u>less</u> harmful than the impulse radios permitted under the Commission's rules. In particular, under severe (I/N=0dB) and moderate (I/N<-6dB) conditions of I/N, the difference between MB-OFDM and WGN was still much less than predicted

[35] Attachment A in Section 3.3 and Attachment C
[36] Freescale Technical Analysis at 12, Figure 4.
[37] For a complete discussion of simulations and lab measurements which showed that MB-OFDM was consistently less interfering in a number of different I/N scenarios than impulse radios already allowed by the rules, see Attachment A in Section 3.4

by Freescale, with the worst case offset being 2dB[38] for I/N=0dB using the worst case TFI code of 1,1,3,3,2,2, with the impulse radio remaining the most harmful interferer. Moreover, these simulation and laboratory measurements closely match the field measurements discussed above. In fact, when the average interference power is well below the noise floor, which should represent the most probable scenario for any victim receiver, there is very little measurable difference between any of the UWB waveforms.

E. MBOA-SIG's APD Analysis is Correct

Freescale claims that MBOA-SIG relied on an erroneous methodology for its APD analysis, thereby producing meaningless comparisons between MB-OFDM and pulsed UWB waveforms.[39] Such allegations are easily refuted, however, by examining the Comments submitted by Philips which provide a detailed discussion of the APD methodology used by MBOA-SIG and explain that it is the same one used by NTIA in its analysis of UWB interference.[40] As both of these analyses demonstrate:

- MB-OFDM shows a less harmful APD plot than impulse UWB for all cases in which (Rx Bandwidth)/PRF > 5;
- In narrow bandwidth cases (<5MHz) MB-OFDM shows a close similarity of the APDs to impulse radios of the same PRF; and
- In wide bandwidth cases (>10MHz) MB-OFDM shows substantially lower peak power than the equivalent PRF impulse radio.[41]

Attachment A supports the use of this methodology and the results obtained.[42]

---

[38] Attachment A, Section 3.4.2. Figure 11 shows 3/4-Rate Coded Results with I/N=0dB and soft decision decoding.
[39] Freescale Technical Analysis at 8.
[40] It is significant that NTIA's own published experimental APD plots for MB-OFDM agree closely with those obtained by simulation and analytical methods. See Progress Report on Signal Generation of Ultrawideband Signals , Task 1 Reprt of "A Study to Define Metrics that Determine the Interference Potential of Various Ultrawideband Waveforms," Mike Cotton et al., June 2004.
[41] Philips Comments at 23.

Freescale's attempt to dismiss the APD results as "flawed methodology and meaningless results" fails to be convincing because no meaningful flaws are pointed out. Furthermore, APD plots do provide helpful insight into the interference properties of a particular waveform (independent of victim receiver characteristics) and are far from meaningless.

III. MB-OFDM Systems Will Comply with the UWB Limits Under the Waiver and Will Not Provide an Advantage Over UWB Technologies.

Freescale asserts that the requested waiver will open the door to "arbitrarily higher power" waveforms, allowing MB-OFDM systems to transmit at greater power than permitted other UWB devices.[43] This assertion is incorrect and serves to underscore Freescale's apparent misunderstanding of the role that peak and average limits provide for UWB devices. As the record indicates, the waiver request deals only with average measurement procedures -- not with peak or average limits. Because all UWB devices are required to comply with both sets of limits, "arbitrarily high power" systems are specifically precluded by the rules.[44] The extreme example given by Freescale of a 3 "hop" system with a 12.5% duty cycle is well outside the scope of the waiver request. Freescale's fears that the MBOA-SIG waiver will somehow erode the power protections built into the UWB rules, therefore, are completely misplaced.[45]

Moreover, the waiver sought by MBOA-SIG will not, as the opponents claim, confer any market advantage on MB-OFDM systems. The waiver request is narrowly drawn, solely to address a measurement anomaly, and does not seek any relief as to UWB emission limits, bandwidth requirements [46] or other Commission rules. In its

---

[42] Attachment A, Section 3.5.
[43] Freescale Comments at 16.
[44] The rules also prevent the gating of pulsed emissions to generate arbitrarily high peak power levels. See Rule 15.521(d).
[45] The scope of this waiver is limited to the 3-band MB-OFDM system and time-frequency codes in the accompanying system description. See Attachment A Section 7 and Attachment B for a more complete description of the MB-OFDM waveform.
[46] Attachment B refutes Motorola's erroneous claim (Motorola Comments at 10) that MB-OFDM systems do not meet the UWB bandwidth minimums. As Attachment B shows, the number of OFDM

technical appendix, however, Freescale speciously argues that "the net effect of this waiver is to allow a special interest group a special dispensation to radiate their bursts at twice the power of everyone else in the industry. This effectively gives one special interest group the ability to double its range, while penalizing all others in the industry with not only less power, but more interference."[47] Of course, this is not true and Freescale knows it, for later in its technical appendix it states, "[i]n fact, another reason the public interest would not be served by granting this waiver is because it would allow higher emission levels, *yet provide the public with not more performance, but less performance*." (Emphasis supplied). [48] Freescale's argument that the waiver will confer an advantage on MB-OFDM is belied by its own words.

In fact, favorable action on the waiver request will neither result in more interference, nor confer an advantage. It will simply put MB-OFDM on an even footing with pulsed UWB systems, equalizing range and data throughput and, thus, providing a competitive alternative to the pulsed UWB systems now coming to market.

IV. The FCC has Sufficient Technical Data and Should Not Await the Results of Further Testing.

Freescale argues that the Commission should not act in this proceeding until it receives the results of certain UWB interference testing being performed under CRADA-funded contract with NTIA/ITS. Freescale is simply engaging in a delaying tactic. The Commission has been supplied with ample technical data showing that MB-OFDM systems do not pose a threat of harmful interference to licensed or unlicensed devices including other UWB systems. Waiting for further test data will serve only to delay unnecessarily Commission action on the waiver request and deny the public the opportunity to chose among competing UWB technologies. It should be noted, moreover, that the scope of the ITS study is much broader than the

---

subcarriers which carry data total 122 (110 data + 12 pilot subcarriers). Thus, the bandwidth of the OFDM symbol is 122*4.125 = 503.25 MHz, which clearly meets the minimum bandwidth requirements for UWB systems, regardless of the time-frequency coding employed by the system.

[47] Freescale Technical Analysis, Section 4.4.1.

[48] Freescale Technical Analysis at 25.

3-band OFDM system that is the subject of this waiver request. The study involves a more general investigation of potential interference from various UWB waveforms, including 7, and 13 band OFDM variants, gated noise with various duty cycles and direct sequence and impulse radio of different PRFs. Thus, while the ITS study may ultimately prove useful to a future Commission rulemaking, there is no reason to consider it in this proceeding.[49]

Freescale also complains that MBOA-SIG tested only one of the four MB-OFDM time-frequency codes and that "[its] own testing suggests the form of the modulation tested is one of the least interfering of the four."[50] Simulation results for the other time-frequency codes are provided in Attachment A, and an evaluation of the APD methodology shows that the different time-frequency codes have identical APD plots.[51] As the data shows, there is very little difference between the various codes (less than 0.5 dB under realistic operating scenarios of I/N < -5 dB), making further testing unnecessary for the requested waiver.

V. MB-OFDM Transmissions Will Not be Coordinated by Users and Will Not Result in Increased Aggregation of Interference Compared to Other UWB Devices.

Freescale has alleged that the waiver will facilitate increased "aggregate interference" from MB-OFDM devices to other UWB devices.[52] This allegation is based, apparently, on informal discussions by some MBOA members at IEEE meetings. The MBOA proposal presented to IEEE, developed through an open committee process among all MBOA members, entertained numerous innovative ideas some of which never found their way into the final proposal. As pointed out in Attachment A, however, the final MB-OFDM proposal does <u>not</u> facilitate any fine-scale coordination among devices such as timing of the OFDM symbol transmissions.

---

[49] It should be noted that the ITS study is only investigating interference to commercial systems and not to governmental radio systems. Thus, the Commission is not required to show deference to NTIA's views on spectrum interference in this matter.
[50] Freescale Comments at 14.
[51] Additional simulation results are provided in Section 3.4 for different time-frequency codes, and Section 3.5 explains why APD plots are identical for the different time-frequency codes since APD analysis is independent of the time scale on which the APDs are computed.
[52] Freescale Comments at 15.

Freescale is similarly wide off the mark in its allegation that an efficient clear channel assessment (CCA) mechanism, described by the MBOA, is a means of implicit coordination among users. It is well known in the engineering community that effective CCA mechanisms are in fact highly desirable. They are used in carrier sense multiple access (CSMA) based networks to improve spectrum efficiency, reduce overall interference and help schedule transmissions by the higher network layers – but not as means of achieving the kind of fine-scale coordination that Freescale implies.

Furthermore, as explained in Attachment A, the potential for power aggregation, to the extent it exists, is the same for MB-OFDM as for DS-UWB waveforms.[53] Both systems are designed to fulfill similar requirements and thus, use the same mechanisms to share available bandwidth in any given piconet. Both systems are designed to use controls to minimize collisions between transmitters that want to access the medium in the same geographic zone. Pursuant to IEEE requirements, both also offer the capability of supporting multiple operating piconets in the same geographic area. In short, there is no greater likelihood of power aggregation from either system when serving multiple piconets in densely populated areas. Allegations to the contrary are simply incorrect.

VI. A Waiver is in the Public Interest Because it Will Provide Users with a Choice Among Competing UWB Technologies.

As MBOA-SIG explained in its Petition, the inherent advantages of MB-OFDM have made it an attractive option for many companies. The overwhelming adoption of this approach by so many companies speaks to this issue. There are several key features that provide tremendous flexibility in system design to meet CE and PC industry needs – today and in the future. The MB-OFDM approach, by its fundamental design of partitioning the spectrum into 528 MHz bands and using three bands for transmission (yielding a total spectrum usage of 1.5 GHz) accomplishes

[53] Attachment A, Section 5.

four key benefits. First, it leverages the inherent energy capture of traditional OFDM technology. Second, it yields lower overall system complexity, especially in the analog portion of the design, as a result of using smaller partitions of the spectrum at an instant in time (e.g. lower bandwidth analog filters, analog to digital converters, etc.). Third, it provides coarse-grained spectral flexibility (since the spectrum is divided into 528 MHZ bands from 3.1 to 10.6 GHz) to accommodate worldwide regulatory development as well as interference mitigation. Fourth, the OFDM signal generation, by its nature, produces much lower out-of -band (OOB) emissions than traditional UWB signals (traditional UWB signals require higher order filters which use more power or add cost to the entire solution). This will allow MB-OFDM transceivers to be located much closer to out-of-band victim receivers (e.g. sharing the same box with cellular phones and 802.11a/b/g transceivers) and will allow MB-OFDM chip makers to achieve an even better OOB mask than required by FCC rules.[54] Finally, MB-OFDM, more so than any other UWB modulation scheme, has inherent spectral shaping capabilities that enable it to mitigate any future unforeseen interference situations that may arise.[55] This makes it possible to co-locate MB-OFDM devices with other technologies such as Bluetooth, Wi-Fi , cellular and even other UWB devices without suffering any significant loss in performance.

The benefits outlined above will provide the consumer with a competitive choice. While the advantages of one UWB architecture over another can be expected to be a source of industry debate, it is clear that consumer will need to consider many factors including complexity, cost, performance, range, and scalability. The important point is that MB-OFDM represents a market alternative to pulsed UWB and one that the Commission should readily encourage and embrace in the public interest.

---

[54] Freescale described one of the listed advantages of MB-OFDM - "flexibility in balancing performance against implementation complexity"- as "incomprehensible". As we have discussed above, the innovative use of 528 MHz bands, coupled with the inherent energy capture benefits of OFDM are precisely the mechanisms which yield the flexibility to yield good performance with low complexity implementations by reducing the requirements on the analog and digital portion of the radio design.

[55] Attachment A, Section 6.2

Conclusion

Based on the foregoing, MBOA-SIG requests that its waiver request be granted promptly by the Commission.

Respectfully Submitted,

Terry G. Mahn
Robert J. Ungar
Fish & Richardson P.C.
1425 K St NW
Eleventh Floor
Washington DC 20005

October 21, 2004

Counsel for MBOA-SIG