

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

In the Matter of )
)
Robert Bosch LLC ) ET Docket No. 20-268
)
)
Request for Waiver of Sections 15.503(d), )
15.503(h), and 15.521(d) of the Commission’s )
Rules )

ORDER

Adopted: January 4, 2022

Released: January 4, 2022

By the Acting Chief, Office of Engineering and Technology:

I. INTRODUCTION

1. By this Order, we grant a request by Robert Bosch LLC (Bosch), for a waiver of our rules governing unlicensed ultra-wideband (UWB) devices to permit the certification and marketing of the newest version of its UWB wall imaging system. We find that opening a path for the sale and operation of this next generation equipment will allow Bosch to deploy its system to enhance the through-wall imaging capabilities for construction professionals, in furtherance of the public interest; and that operation of this device under the specified waiver conditions poses no greater risk of causing harmful interference to communication services than those devices already permitted under the existing rules.

II. BACKGROUND

2. On April 13, 2020, Robert Bosch LLC (Bosch) filed a request for waiver of the Commission’s Part 15 ultra-wideband (UWB) rules to allow the marketing and operations of its frequency hopped UWB wall imaging system, known as the Wallscanner D-tect 200 Professional (D-tect 200).<sup>1</sup> Bosch states that the D-tect 200 is a tool for skilled professional deployment in the construction trade, used for detection and inspection of ferrous and non-ferrous metals, electric cables, wooden beams, plastic pipes, and for identification of structural flaws within construction materials. According to the request, the device operates between 1.8 GHz and 5.7 GHz, and hops continuously over the complete operating frequency range from lowest to highest frequency.<sup>2</sup> Bosch states that the application and use of the D-tect 200 is “precisely the same as” its predecessor, the D-tect 150,<sup>3</sup> for which we had previously

<sup>1</sup> Robert Bosch LLC Request for Waiver of Section 15.503(h) of the Commission’s Rules to Permit the Marketing, Sale and Operation of Ultra-Wideband Wall Imaging Device; and Waiver of Section s 15.503 (d) and 15.521(d) of the Commission’s Rules Governing Minimum Bandwidth (Bosch waiver request), filed April 13, 2020.

<sup>2</sup> See Bosch Comments at 1-2.

<sup>3</sup> See Bosch waiver request at 3.

granted a waiver of the definitional requirement in Section 15.503(h) of our rules.<sup>4</sup> The D-tect 150 otherwise operates under our existing rules; as Bosch points out, it uses pulse modulation and operates between the frequency range of 2.2 - 5.8 GHz.<sup>5</sup> The new device, the D-tect 200, incorporates design revisions including changes in circuitry that would not permit it to be authorized under the existing certification issued for the D-tect 150.

3. Specifically, Bosch seeks a rule waiver to permit it to use a frequency hopping configuration, which is new to the D-tect model design.<sup>6</sup> Bosch asks for a waiver of section 15.503(d), which requires that a UWB transmitter at any point in time have a fractional bandwidth equal to or greater than 0.20 or a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth. Bosch also requests a related waiver of section 15.503(h), which lays out the definition for a wall imaging system, and Section 15.521(d), which requires that if pulse gating is employed where the transmitter is quiescent for intervals that are long compared to the nominal pulse repetition interval, measurements shall be made with the pulse train gated on. A waiver of Sections 15.503(d), 15.503(h), and 15.521(d) of the rules is needed so that Bosch can perform measurements to demonstrate compliance with the rules, while the system is operating in its normal transmission mode, and so that Bosch can market the D-tect 200 devices. Finally, Bosch has also committed to no longer manufacturing equipment under its previous waiver should its instant request be granted.<sup>7</sup>

4. On August 20, 2020, the Office of Engineering and Technology (OET) sought comment on Bosch's request.<sup>5</sup> The Comment cycle ended on October 19, 2020. GPS Innovation Alliance (GPSIA) was the only party aside from Bosch to file comments in the docket. GPSIA does not oppose the grant of the specific waiver request, noting that Bosch does not propose to operate in the Global Navigation Satellite System (GNSS) band of particular interest to GPSIA, and that the definitional issue that Bosch raises is "effectively similar to" relief we previously granted to Bosch in 2011.<sup>8</sup> However, GPSIA expresses general concerns about the Commission's rule waivers affecting UWB devices due to the proximity of some UWB device operations to spectrum used by GNSS receivers. It asks us to "exercise great caution" in granting waivers and ensure that waiver requests continue to be "based on specific and unique circumstances that warrant a discrete waiver of the specific rule."<sup>9</sup> For this particular waiver request, it asks us to impose conditions on Bosch to ensure that its device is used for professional use (as opposed to being a general consumer use device).<sup>10</sup> Finally, to assist interested parties in evaluating future petitions filed with the Commission, GPSIA states that we should require UWB rule waiver applicants to provide specific technical information at the time they initiate a request for a waiver.<sup>11</sup>

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<sup>4</sup> Robert Bosch, GmbH Request for Waiver of Part 15 Ultra-wideband Rule for a Wall Imaging Device, ET Docket No. 10-253, Order, 26 FCC Rcd 7572 (OET 2011) (Bosch 2011 Waiver Order).

<sup>5</sup> See Letter from Christopher D. Imlay, Counsel to Robert Bosch, to Chief, Office of Engineering and Technology, FCC, filed in ET Docket 20-268 on July 28, 2021, at 3 (Bosch July 28, 2021 *ex parte*).

<sup>6</sup> See Bosch waiver request at 2.

<sup>7</sup> See Letter from Scott Delacourt, Counsel to Robert Bosch, to Marlene Dortch, Secretary, FCC, Dec. 29, 2021 (also discussing several conditions that Bosch would be able to meet if they were included in a waiver grant).

<sup>8</sup> GPSIA Comments at 1-2.

<sup>9</sup> *Id.* at 2.

<sup>10</sup> *Id.* at 5-6.

<sup>11</sup> *Id.* at 6.

### III. DISCUSSION

5. We are authorized to grant a waiver under Section 1.3 of the Commission's rules if the petitioner demonstrates good cause for such action.<sup>12</sup> Good cause, in turn, may be found “where particular facts would make strict compliance inconsistent with the public interest.”<sup>13</sup> To make this public interest determination, the waiver cannot undermine the purpose of the rule, and there must be a stronger public interest benefit in granting the waiver than in applying the rule.<sup>14</sup> The UWB standards in Part 15 were adopted to ensure that UWB devices, including wall imaging systems, do not cause harmful interference to authorized radio services, including those operated by the Federal Government.<sup>15</sup> As discussed below, we find that, with appropriate operational and technical limitations, granting Bosch’s request for waiver poses no greater risk of causing harmful interference to radio communications services than any other wall imaging device operating under our rules. In addition, we find that there is a stronger public interest benefit in granting this waiver than in strictly applying the rules. In the waiver order previously granted to the D-tect 150 the Commission found that a waiver of the rules would allow deployment of a product with beneficial applications in building construction, as well as inspection and maintenance of buildings in the United States. That analysis continues to apply because, the D-tect 200 device improves on but otherwise serves the same function as the D-tect 150. The design changes are intended to provide greater resolution and precision in detecting materials through walls which in turn, can enhance safety and increase efficiency for construction professionals. Thus, we find that the waiver standard has sufficiently been met.

#### A. Waiver of the UWB definition in Section 15.503(d)

6. Section 15.503(d) of the Commission’s rules defines a UWB transmitter as a device that “at any point in time” has an UWB bandwidth equal to or greater than 500 megahertz or a fractional bandwidth equal to or greater than 0.20.<sup>16</sup> Bosch describes the D-tect 200 as using frequency-hopped emissions.<sup>17</sup> The transmitted signal hops continuously over the frequency range from 1.8 GHz and 5.7 GHz. The signal has a bandwidth of less than 1 kHz, an on-time of no less than 50 microseconds, an off-time of 15 microseconds or less, and 30 discrete hops. It also has the maximum time for each hop sequence of 2.3 milliseconds. Each of these individual transmissions is less than 500 megahertz in bandwidth “at any point in time” and Bosch’s device does not have a 0.20 or greater fractional bandwidth. Thus, even though the device operates over a frequency range that exceeds 500 megahertz, it would not meet the definitional requirement for operation under the UWB rules.<sup>18</sup>

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<sup>12</sup> 47 CFR § 1.3. See also *ICO Global Communications (Holdings) Limited v. FCC*, 428 F.3d 264 (D.C. Cir. 2005); *Northeast Cellular Telephone Co. v. FCC*, 897 F.2d 1164 (D.C. Cir. 1990); *WAIT Radio v. FCC*, 418 F.2d 1153 (D.C. Cir. 1969).

<sup>13</sup> *Northeast Cellular*, 897 F.2d at 1166; see also *ICO Global Communications*, 428 F.3d at 269 (quoting *Northeast Cellular*); *WAIT Radio*, 418 F.2d at 1157-59.

<sup>14</sup> See, e.g., *WAIT Radio*, 418 F.2d at 1157 (stating that even though the overall objectives of a general rule have been adjudged to be in the public interest, it is possible that application of the rule to a specific case may not serve the public interest if an applicant's proposal does not undermine the public interest policy served by the rule); *Northeast Cellular*, 897 F.2d at 1166 (stating that in granting a waiver, an agency must explain why deviation from the general rule better serves the public interest than would strict adherence to the rule).

<sup>15</sup> *Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*, ET Docket No. 98-153, First Report and Order, 17 FCC Rcd 7435 (2002) (*UWB First R&O*); see also, 47 CFR §§ 15.501-15.525.

<sup>16</sup> 47 CFR §15.503(d).

<sup>17</sup> See Bosch Comments at 1-2.

<sup>18</sup> Stepped frequency, swept frequency, and frequency hopped devices like Bosch’s D-tect 200 have a difficult time meeting the rule’s technical specifications because the large bandwidth is achieved by stepping or sweeping a

(continued....)

7. The UWB imaging rules were designed to accommodate devices that emit impulsive or transient-like signals that are spread across a very wide bandwidth to produce an image of objects within the ground or other materials.<sup>19</sup> The primary difference between the Bosch device and other UWB wall imaging devices provided for in the rules is that the D-tect 200 does not transmit a single impulsive signal but instead transmits sequentially in hops over a large band of spectrum to gather all the needed data. In the past the Commission has determined that frequency agile UWB devices may perform in a manner that is equivalent to non-frequency agile devices.<sup>20</sup> For example, in the waivers granted to Curtiss-Wright Controls Inc., Proceq USA Inc., and more recently the Massachusetts Institute of Technology, the Commission recognized that stepped frequency UWB devices were functionally equivalent to other UWB devices and that the risk of interference from the associated devices would be no greater than from other UWB devices.<sup>21</sup> Here we find that the D-tect 200 devices is functionally equivalent to other types of UWB wall imaging devices in that it uses transient-like signals spread across a wide bandwidth to detect objects behind concrete and other construction materials. The risk of interference is comparable to that from other such UWB wall imaging, such as the previous iteration of the D-tect 150 device,<sup>22</sup> and so a waiver in this case will not undermine the intent of our rule.

**B. Waiver of the measurement procedures in Sections 15.521(d) and 15.31(c)**

8. Section 15.521(d) sets forth the measurement procedures for UWB devices to demonstrate compliance with applicable emissions limits.<sup>23</sup> For emissions above 960 MHz, this rule requires that, if pulse gating is used and the transmitter is quiescent for longer intervals than the nominal pulse repetition interval, measurements are made with the pulse train gated on. Bosch asserts that for reasons equally applicable to D-tect 200, the Commission granted a waiver to Curtiss-Wright Controls Inc. of Sections 15.503(d) and 15.521(d) of the Commission's Rules due to the restrictive means of determining the minimum operational bandwidth of a UWB transmitter contained in the rule.<sup>24</sup> Bosch claims that the D-tect 200 will meet all other Subpart F, Part 15 rules and other applicable Part 15 rules, and Bosch will have the device certified as an intentional radiator under applicable parts of the Commission's Rules.<sup>25</sup> Additionally, we recognize from Bosch's filing that the D-tect 200 will also require a waiver of Section

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narrow signal through the broader frequency range, and therefore won't be instantaneously wide enough to meet the rules' specific requirements.

<sup>19</sup> See *UWB First R&O*, 17 FCC Rcd at 7437-7440, 7450, 7476 and 7494.

<sup>20</sup> See *Petition for Waiver of the Part 15 UWB Regulations Filed by the Multi-band OFDM Alliance Special Interest Group*, ET Docket No. 04-352, Order, 20 FCC Rcd 5528 (2005) (MBOA-SIG Waiver), as well as *Curtiss-Wright Controls Inc. Request for Waiver of Part 15 of the Commission's Rules Applicable to Ultra-Wideband Devices*, ET Docket No. 10-167, Order, 27 FCC Rcd 234, (OET 2012) (CWCI Waiver) and *Kyma Medical Technologies Ltd., Request for Waiver of Part 15 of the Commission's Rules Applicable to Ultra-Wideband Devices*, ET Docket No. 15-119, Order, 31 FCC Rcd 9705 (OET 2016) (Kyma Waiver), *Proceq USA Inc. Request for Waiver of Part 15 of the Commission's Rules Applicable to Ultra-Wideband Devices*, DA -18-251, Order, 33 FCC Rcd 2258, (OET 2018) (Proceq Waiver), *Massachusetts Institute of Technology Request for Waiver of Part 15 of the Commission's Rules Applicable to Ultra-Wideband Devices*, ET Docket No. 19-89, Order, 35 FCC Rcd 4389 (2020) (MIT Waiver).

<sup>21</sup> See CWCI Waiver, See also Proceq Waiver and MIT Waiver.

<sup>22</sup> See Bosch July 28, 2021 *ex parte*, Exhibit A at slides 6-9. Bosch demonstrates that the both the D-tect 150 and the D-tect 200 have comparable transmit EIRP characteristics. Bosch also shows that both devices will comply with the regulated emissions limits.

<sup>23</sup> 47 CFR §15.521(d).

<sup>24</sup> See Bosch Waiver Request at 7-9 (citing waiver requests by Curtiss-Wright Controls, and Bosch D-tect 150).

<sup>25</sup> *Id.* at 21.

15.31(c)<sup>26</sup> of the Commission’s rules which sets forth the measurement standards for unlicensed devices to demonstrate compliance with applicable emission limits. This rule requires that measurement of swept frequency equipment shall be made with the frequency sweep stopped and this requirement has been traditionally interpreted to also be applicable to stepped, hopped, and other frequency diverse modulations schemes. However, application of the requirement to stop the frequency hop when performing compliance measurements would result in a fundamental emission bandwidth measurement that will not comply with the UWB bandwidth requirements.

9. We recognized in prior orders granting waivers of the measurement procedures for UWB transmitters, where emissions were permitted to be measured with the transmitter operating in its normal transmission mode, that the interference aspects of a transmitter employing frequency hopping, frequency stepping, or gating are quite similar, as viewed by a receiver.<sup>27</sup> That is because transmitters using these burst formats appear to the receiver to emit for a short period of time followed by a quiet period.<sup>28</sup> We concluded that “any requirement to stop the frequency hopping, band sequencing, or system gating serves only to add another unnecessary level of conservatism to already stringent UWB standards.”<sup>29</sup> In conjunction with NTIA, we have further determined that allowing stepped frequency devices to be measured with the stepping function on would not increase the interference potential of the device above that of impulse UWB devices if all other emission limits and technical requirements are met.<sup>30</sup>

10. Bosch’s request represents an analogous situation. Because a waiver of the measurement procedures in Sections 15.31(c) and 15.521(d) will not increase the potential for harmful interference to authorized services, permitting Bosch to demonstrate compliance with the UWB emission limits with the stepping function active will not undermine the purpose of the rule.<sup>31</sup> To ensure that the D-tect 200 device does not emit in any individual 1 megahertz or narrow band continuously, we include a duty cycle in our waiver conditions.<sup>32</sup> In sum, we find that permitting Bosch to demonstrate compliance with the UWB wall imaging system emission limits under a waiver of the measurement procedures under the conditions specified below poses no greater risk of causing harmful interference to radio communications services than any other UWB wall imaging system operating under our rules, and therefore will not undermine the purpose of these rules.

### C. Waiver of the UWB definition in Section 15.503(h)

11. Section 15.503 (h) of the Commission’s rules defines a wall imaging system as: A field disturbance sensor that is designed to detect the location of objects contained within a “wall” or to determine the physical properties within the “wall.” The “wall” is a concrete structure, the side of a bridge, the wall of a mine or another physical structure that is dense enough and thick enough to absorb the majority of the signal transmitted by the imaging system. This category of equipment does not include products such as “stud locators” that are designed to locate objects behind gypsum, plaster or similar walls that are not capable of absorbing the transmitted signal.<sup>33</sup> According to Bosch, the D-tect-200 is not entirely consistent with this definition as it will not always be the case that the scanned

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<sup>26</sup> 47 C.F.R. §15.31(c).

<sup>27</sup> See, e.g., MBOA-SIG Waiver, Kyma Waiver and, Proceq Waiver, MIT Waiver.

<sup>28</sup> See, e.g., CWCI Waiver.

<sup>29</sup> *Id.*

<sup>30</sup> See *Id.* See also MBOA-SIG Waiver Order, 20 FCC Rcd at 5531-5536.

<sup>31</sup> Our reliance on the MBOA-SIG Waiver and the CWCI Waiver decision in this instance is only relative to the measurement procedure in Section 15.521(d).

<sup>32</sup> See *infra* para. 15, condition 4.

<sup>33</sup> 47 C.F.R. §15.503(h).

structure will be dense and thick enough to absorb the entirety of the transmitted signal and the device can function as a stud locator.<sup>34</sup>

12. Bosch's predecessor device, the D-tect 150 shared these same characteristics. OET waived Section 15.503(h) for the D-tect 150 concluding that this would not increase the potential for harmful interference to authorized services because the technical and operational provisions of Section 15.509 remain in place to limit harmful interference.<sup>35</sup> In granting the waiver, OET also noted that the device would be useful only to those engaged professionally in building and construction which meets the Commission's intention to limit proliferation of UWB imaging devices to coordinated and controlled ranges of applications in order to limit their interference potential. For these same reasons, we conclude that waiver of Section 15.503(h) is warranted for the D-tect 200. According to Bosch, the D-tect 200 will meet the technical requirements of Section 15.509.<sup>36</sup> The D-tect 200 is also intended for use by those in the building and construction industry.<sup>37</sup> Given that the D-tect 150 has been authorized since 2011 without any reports of harmful interference, we see no reason to reach a different conclusion on waiving Section 15.503(h) for the D-tect 200. While no conditions were associated with the D-tect 150 waiver, we find that generally the D-tect 200 device will have minimum utility by consumers or those not involved in the building and construction trades. However, we do see merit in GPSIA's assertion that this waiver should be conditioned on marketing and operating the D-tect 200 to those engaged professionally in the building and construction trades. We will also include a condition that prohibits the marketing of the D-tect 200 device for retail consumer markets and require analogous labeling statements. These conditions are designed to add an additional level of protection, as Bosch has stated that the application and use of the D-tect 200 is the same its predecessor and we are aware of no complaints that it has been marketed to or subject to popular use by non-professional users.

13. To further ensure that the purpose of the rule is not undermined, we will limit the number of devices that may be deployed under this waiver to six thousand (6000) per year.

#### **D. Waiver conditions**

14. This Order is narrowly tailored to address the particular facts relevant to the Bosch device and is conditioned on Bosch meeting the specified waiver conditions. Because the D-tect 200 must comply with these rules, and because it can operate under a waiver of the four rules we have identified in a manner consistent with the use characteristics associated with other UWB wall imaging applications without increasing the potential for harmful interference to authorized users, we find good cause to grant the waiver request. In doing so, we specifically address the particular circumstances related to the Bosch petition and agree with GPSIA that we will need to carefully evaluate future Part 15 UWB waivers based on the specific and unique circumstances associated with each application. The general concerns about issuing future Part 15 UWB waivers that GPISA has raised in its comments remain available for our consideration later and in an appropriate context. Furthermore, we will not use this proceeding to establish a new precedent for UWB rule waiver applicants to provide specific technical information in their petitions, as GPSIA has asked. We believe that applicants should continue to have broad flexibility in how they choose to structure their petitions. As a practical matter, because parties must submit sufficient information to mitigate the risk of delayed consideration or outright dismissal of their petitions, there is ample incentive for them to make their filings as complete and detailed as practical.

15. Our waiver is limited to the Bosch D-tect 200 device as manufactured, marketed and/or sold by Robert Bosch LLC and its affiliates and its use as described in the waiver request, and applies to: 1) the instantaneous bandwidth requirement in 47 CFR §15.503(d) as waived to permit operation of the

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<sup>34</sup> Bosch Waiver Request at 8, 14-15; Bosch Comments at 1-2.

<sup>35</sup> Bosch 2011 Waiver Order, 26 FCC Rcd at 7574, para. 8.

<sup>36</sup> Bosch Waiver Request at 13-14.

<sup>37</sup> Bosch Comments at 2.

frequency-hopped UWB wall imaging system; 2) the measurement requirements in 47 CFR §§15.31(c) and 15.521(d) as waived to permit the D-tect 200 device to be tested with the frequency sweep, stepping, or frequency hopping function active, rather than stopped, to demonstrate compliance with the maximum permitted average power in 47 CFR §15.509; 3) the definitional requirement in 47 CFR §15.503(h) as waived to permit the operation of a wall imaging system or a field disturbance sensor that is designed to detect the location of objects contained within a “wall” or to determine the physical properties within the “wall.” that is operated on materials that may or may not be thick enough to absorb the majority of the signal transmitted by the imaging system to permit limited usage of a drywall scanner/stud finder function of the device. This waiver is subject to the following conditions:

- 1) The D-tect 200 single hop step shall have a bandwidth of less than 1 kHz.
- 2) The intentional emissions generated by the D-tect 200 must be completely contained within the 1.8 to 5.7 GHz frequency range.
- 3) The D-tect 200 shall operate with frequency hopped modulation in 30 steps between 1.8 and 5.7 GHz.
- 4) The D-tect 200 maximum average transmission on-time shall be no less than 50 microseconds, the average transmission off-time shall be 15 microseconds or less. The maximum of the average ramp time shall be 2.3 milliseconds, resulting the maximum average dwell time to be 77 microseconds (2.3 milliseconds / 30 steps = 77 microseconds).
- 5) The device shall include a feature to ensure that it will only transmit when placed in contact with or close proximity to the building structure being measured and/or evaluated.
- 6) The D-tect 200 will not transmit continuously and will cease transmission 10 seconds after no movement.
- 7) For certification testing, the measurement of the emissions from the Bosch D-tect 200 shall be conducted with the hopping function active.
- 8) The D-tect 200 devices shall comply with all other technical and operational requirements applicable to UWB wall imaging devices under Part 15, Subpart F of the Commission’s rules.
- 9) The waiver conditions granted herein are not transferable to any third party via §2.933 or any other means of technology transfer.
- 10) This waiver and its conditions shall apply only to the UWB devices described herein and are not to be considered to apply generally to any other UWB operations where further analysis would be necessary to assess the potential for impact to other authorized users.
- 11) The total U.S. sales of D-tect 200 devices shall not exceed 6000 devices, annually.
- 12) The D-tect 200 device shall not be marketed for retail consumer markets. The D-tect 200 device will be used by those engaged professionally in the building and construction trades.
- 13) The D-tect 200 device package shall include labeling stating “For professional use only.”
- 14) The user manual for the D-tect 200 will clearly state that “Device operation is limited to those engaged professionally in the building and construction trades.”
- 15) Upon grant of this waiver, Bosch will abide by its commitment to no longer manufacture equipment under the waiver, DA 11-899, granted by OET on May 23, 2011 in ET Docket No. 10-253.
- 16) A copy of this Order shall be provided with the application for certification of the device.

**IV. ORDERING CLAUSES**

16. Accordingly, pursuant to authority delegated in Sections 0.31 and 0.241 of the Commission's rules, 47 CFR §§ 0.31, 0.241, and Section 1.3 of the Commission's rules, 47 CFR § 1.3, IT IS ORDERED that the Request for Waiver filed by Robert Bosch LLC on April 13, 2020 IS GRANTED consistent with the terms of this Order. This action is taken pursuant to Sections 4(i), 302, 303(e), and 303(r) of the Communications Act of 1934, as amended, 47 U.S.C. Sections 154(i), 302, 303(e), and 303(r). This action is effective upon release of this Order.

17. IT IS FURTHER ORDERED that, if no applications for review are timely filed, this proceeding SHALL BE TERMINATED and the docket CLOSED.

FEDERAL COMMUNICATIONS COMMISSION

Ronald T. Repasi  
Acting Chief  
Office of Engineering and Technology