Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, D.C. 20554

In the Matter of	**)**	
	)	
Amendment of Rules Governing Ultra-Wideband	**)**	**RM -**
Devices and Systems	**)**	

To: The Chief
Office of Engineering and Technology
Via: ECFS

PETITION FOR RULE MAKING

Robert Bosch LLC (Bosch), a leading global supplier of technology and services,[1] by counsel and pursuant to Section 1.401 of the Commission's Rules (47 C.F.R. § 1.401), hereby respectfully requests that the Commission initiate at an early date a comprehensive review of the Part 15, Subpart F regulations governing Ultra-Wideband (UWB) devices and systems. Bosch also requests that the Commission adopt the modified rules for UWB operation proposed in the attached Appendix regarding UWB devices and systems. These amended rules will facilitate the development and provision of new, innovative UWB products in the United States marketplace by manufacturers. Many such products and systems are not permitted by the current UWB rules, due to a conservative initial regulatory environment created for this technology by the Commission sixteen years ago. Experience with the technology since that time has demonstrated that interference fears of both the National Telecommunications and Information Administration

[1] Bosch offers innovative solutions for smart homes, smart cities, connected mobility, and connected manufacturing. It uses its expertise in sensor technology, software, and services, as well as its own IoT cloud, to offer its customers connected, cross-domain solutions from a single source. Bosch has conducted extensive research and development in, and has several products now available and in development using UWB technology. The development of products for use in the United States, however, is substantially inhibited by the preclusive and inflexible regulatory structure of the Subpart F, Part 15 rules, the content of which are, and have since their adoption been acknowledged to have been overly conservative.

(NTIA) and private sector telecommunications entities, expressed long ago in Docket 98-153 relative to UWB overlays in allocated spectrum used for narrow bandwidth emissions, were unfounded. The conservative regulations adopted are not necessary to prevent interference to narrow bandwidth incumbents. Nor is there evidence of increases in ambient noise from aggregate UWB devices and systems that have become operational during the long interval between 2002 when the rules were first adopted, and the present time. There is a need to harmonize the UWB rules with those in Europe and elsewhere to facilitate a worldwide marketplace for standardized UWB products. Doing so would also provide a benefit to companies operating and manufacturing in the United States. The UWB rules that should be reviewed now include technical rules applicable to the testing and equipment authorization of all UWB systems which were adopted in 2002, and the definitional and operational rules that limit the categories of UWB devices and systems that can receive grants of certification under the Commission's equipment authorization procedures, and hence the ability to market and sell the devices to end users. The current UWB rules (principally but not exclusively the technical and definitional rules) are so stringent that of necessity, virtually all new UWB products and systems must apply to the Commission for, and be subject to a waiver as an incident of being granted certification for marketing and sale of the device in the United States. There is a well-established and acknowledged need to revisit the UWB rules – something that the Commission always intended to do – to allow new, useful, innovative and spectrum-efficient UWB products to be brought to the United States marketplace, as they are now in most other countries of the world. For its Petition, Bosch states as follows:

I. Introduction and Background.

1. The Commission has repeatedly stated that its rules governing various types of UWB devices and systems were, generally speaking, overly conservative *ab initio*. In its *First Report and Order*, FCC 02-48, 17 FCC Rcd. 7435 (2002) in Docket 98-153, the Commission, proceeding "cautiously," established what it referred to as a potentially "overprotective" regulatory scheme for then-nascent UWB technology, which technology nonetheless was found to offer "significant benefits" for public safety, businesses and consumers:

> UWB technology holds great promise for a vast array of new applications that we believe will provide significant benefits for public safety, businesses and consumers. With appropriate technical standards, UWB devices can operate using spectrum occupied by existing radio services without causing interference, thereby permitting scarce spectrum resources to be used more efficiently. This First Report and Order ("Order") includes standards designed to ensure that existing and planned radio services, particularly safety services, are adequately protected. We are proceeding cautiously in authorizing UWB technology, based in large measure on standards that the National Telecommunications and Information Administration ("NTIA") found to be necessary to protect against interference to vital federal government operations. These UWB standards will apply to UWB devices operating in shared or in non-government frequency bands, including UWB devices operated by U.S. Government agencies in such bands. We are concerned, however, that the standards we are adopting may be overprotective and could unnecessarily constrain the development of UWB technology. Accordingly, within the next six to twelve months we intend to review the standards for UWB devices and issue a further rule making to explore more flexible technical standards and to address the operation of additional types of UWB operations and technology.
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> (*First Report and Order*, 17 FCC Rcd. at 7435)

2. There were two principal reasons that the Commission proceeded so cautiously in authorizing this then-new technology in 2002. The first was that the comments filed in the Docket proceeding initiated in 1998 were somewhat contentious, and the commenting parties were not able to agree on emission levels necessary to protect various radio systems from harmful interference. Second, NTIA asked that strict rules be applied to UWB devices and

systems. Because of their wide operating bandwidths, UWB devices and systems operate in frequency bands that are allocated both to U.S. Government and to non-government operations. The standards and operating requirements were based in part on standards that NTIA found necessary to protect against interference to Federal government operations. Of special concern was the fact that the occupied bandwidth of some UWB devices might include some, or portions of some of the Part 15 "restricted bands" listed in Section 15.205 of the Commission's rules where intentional radiators were not permitted to operate. The restricted bands are designated so as to protect sensitive or critical government and passive radio services such as radioastronomy from interference.

3. The Commission therefore clearly noted in 2002 that the standards contained in the *First Report and Order* were "extremely conservative" and that they might change in the future as the Commission continued to collect data regarding UWB operations. *Id.*, at 7436. In the intervening sixteen years, however, there have been no documented complaints of interference from UWB devices as far as Bosch has been able to determine, and there are no known residual debates ongoing in technical literature dealing with determination of the proper emission levels. Nevertheless, the intended review of the conservative UWB rules, which was to occur "six to twelve months" after the 2002 First Report and Order, never materialized. The Commission has maintained definitional and eligibility rules that are inconsistent and preclusive during the entire period between July of 2002 when the UWB rules first took effect and the present time, sixteen years later. It has also prohibited entire categories of use cases for UWB and it has established a virtual case-by-case, device-by-device "authorization by waiver" process for most, if not all, UWB products that is wasteful of Commission resources and which creates expense and significant delay in bringing new, desired products to the United States marketplace. Nor has any

comprehensive further rulemaking been commenced to re-examine the overly conservative initial rules occurred during this time.

4. The Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT) and the European Telecommunications Standards Institute (ETSI) have collaborated in Europe during this same period to harmonize UWB regulations worldwide. ETSI prepared an ITU input document as recently as November of 2016 with worldwide UWB harmonized regulation as a goal.[2] Furthermore, UWB regulation in the ECC is summarized in ETSI TR 103 181-1 and ETSI TR 103 181-2;[3] and the currently open discussion within the ECC is premised on some recent studies intended to arrive at appropriate international standards for UWB regulation.[4] ECC published an update of the regulation in the revision of ECC/DEC/(06)04 and ECC/DEC(07)01. The EC DEC publication is expected in May of 2019.[5] The new ECC rules provide, as an example, a provision for UWB operation in vehicles. There are included new interference mitigation techniques which will allow widespread deployment of, as but one example, keyless entry systems which are far more effective than are

[2] See, ITU-R WP1A/B meeting Nov 2016 input document.

[3] See, ETSI TR 103 181-1 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band (UWB);Transmission characteristics; Part 1: UWB signal characteristics and overview CEPT/ECC and EC regulation" and ETSI TR 103 181-2 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band (UWB);Transmission characteristics; Part 2: UWB mitigation techniques."

[4] See, ETSI TR 103 416 (V1.1.1): "Short Range Devices (SRD) using Ultra Wide Band (UWB); Transmission and Technical characteristics for SRD equipment using Ultra Wide Band (UWB); System Reference Document for UWB based vehicular access systems;" ETSI TR 103 313 (V1.1.1): "System Reference document (SRdoc); Short Range Devices (SRD) using Ultra Wide Band (UWB); Technical characteristics for SRD equipment using Ultra Wide Band Sensor technology (UWB); Medical, wellness and assisted living applications;" and ETSI TR 103 314 (V1.1.1): "System Reference document (SRdoc); Short Range Devices (SRD) using Ultra Wide Band (UWB); Technical characteristics for SRD equipment using Ultra Wide Band Sensor technology (UWB) based on amended mitigation techniques for UWB."

[5] See, ECC Decision (07)01, *The harmonised use, exemption from individual licensing and free circulation of Material Sensing devices using Ultra-Wideband (UWB) technology* (Approved 30 March 2007, as amended). In this updated Decision, It is noted that is a significant market demand for UWB material sensing devices. The ECC Decision seeks to ensure that "frequency bands are available on a harmonised basis to enable the introduction of UWB devices in a timely manner and ensuring economies of scale while ensuring protection of existing applications or services."

current narrowband Low-Frequency/or UHF solutions. Also in these new ECC rules, the UWB provisions for devices that perform material sensing are of wider, more generic application, focusing on two classes[6] of such devices, one of which could be safely utilized outdoors. [7] In addition to the new ECC and EC rules, the ECC study of generic outdoor/fixed usage is ongoing. The results (in the form of a permanent EC mandate) will be implemented during the ongoing update of the EC rule. [8]

5. In the 2002 *First Report and Order* in the UWB proceeding, beginning at paragraph 122, the Commission analyzed an extensive study by NTIA of the interference potential of UWB terrestrial operation to various government telecommunications and electronic systems. The purpose was to determine appropriate UWB radiated emission levels which could be permitted without causing interference to those systems. The ultimate conclusion was that, because UWB devices would in the worst case create noise-type interference due to increases in the apparent noise floor, the interference potential at the radiated emission levels permitted by the Commission's rules would result in adequate protection for government communications systems from UWB devices and systems. The NTIA study was important in order to determine the proper radiated emission levels from UWB devices that would operate in, *inter alia,* the Part

[6] Material sensing devices are in ECC/DEC/(07)/01 split into two classes of sensing and imaging devices These classes are: (1) Contact-based sensors and imaging devices in which the UWB transmitter is switched on only when in direct contact with the material under investigation; and (2) Non-contact-based sensor and imaging devices, in which the UWB transmitter is switched on only when in close proximity with the investigated material and the UWB transmitter is directed into the direction of the material under investigation (e.g. manually, by using a proximity sensor or by mechanical design).

[7] This is because more flexible interference mitigation provisions can be incorporated. These might include mechanical design, and requirements for sensors to be in close proximity to the material being evaluated. For example, for parking sensors, the UWB automotive dev ice, in order to operate at full power would have to be located directly over the parking sensor. The new differentiated classes of UWB dev ice in place in Europe permit multiple material sensing use cases instead only through-wall and GPR/WPR devices. The point is that the United States is far behind the rest of the world in UWB technology innovation because the waiver process for UWB devices is outdated, inflexible, cumbersome, expensive, and, for modern manufacturing, thus unworkable.

[8] A new update of the EC rule is planned for 2021. It will be the second update of the permanent mandate.

15 "restricted bands" [9] without a predictable interference potential. To the extent that NTIA's concern about operating in the restricted bands was premised on fears of interference to military systems, the ECC's recently revised regulations regarding UWB reflect NATO's considerations, and that has not hampered the development of UWB rules in Europe which are now more flexible than the restrictive rules in the United States. In any case, it was quite clear that the Commission in 2002 was not satisfied that its rules were sufficiently flexible to permit the development of useful products and systems using this new technology:

> We find that there is sufficient information in the record to make initial decisions at this time that provide for the introduction of UWB technology based on standards that are extremely conservative in protecting radio services against harmful interference. We recognize, however, that as this technology develops and we gain experience with the potential interference of UWB devices, it is appropriate to reexamine these rules. Accordingly, within the next six to twelve months we intend to review the standards for UWB devices and issue a further rule making to explore more flexible technical standards and to address the operation of additional types of UWB operations and technology.
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> (*First Report and Order*, 17 FCC Rcd. at 7525)

The Commission did in fact peripherally revisit the UWB rules in a *Second Report and Order and Second Memorandum Opinion and Order*, (*Second R&O*), FCC 04-285, 19 FCC Rcd. 24558 (released December 16, 2004). The stated purpose of the *Second R&O* was to "amend Part 15 of [the] rules to provide greater flexibility for the introduction of new wide-bandwidth devices and systems." However, *there was not any amendment of the specific rules applicable to UWB devices,* but instead, only the amendment of the general Part 15 rules. The Commission again expressed reluctance to "change the existing UWB rules until we have more experience with UWB devices (footnote omitted). We continue to believe that any major changes to the rules for existing UWB product categories at this early stage would be disruptive to current industry

[9] 47 C.F.R. § 15.205.

product development efforts." *Id.*, 19 FCC Rcd. at 24560. Thus, the Second R&O merely adopted rules dealing with wide-bandwidth part 15 devices.

6. There has not, in fact, been any significant review of the UWB rules since the adoption of the *Report and Order* in Docket 98-153 in 2002. It is not disputed that the Commission properly, in a somewhat controversial rulemaking proceeding, proceeded cautiously and conservatively in adopting initial rules which it intended to: (1) encourage the development of new UWB applications, while at the same time (2) clearly protect, *ex ante*, incumbent licensed and government radio services against interference. However, it has now been sixteen years since the adoption of the restrictive UWB rules which have notably limited the manufacture and availability of UWB products which are in successful use outside the United States. Nor has there ever been any revisiting of those rules as the Commission promised to do. As far as Bosch can determine, there are no documented instances of interference from any UWB device to a licensed radio service. The rules, however, have clearly created a significant obstacle to the implementation by Bosch and many other business entities of useful UWB technology which can enhance and facilitate building and construction efforts substantially; assist in assessing and repairing and diagnosing flaws in infrastructure; increase security; provide communications service; and save costs, money and time, without any substantial interference potential. The Commission's rules, which the Commission expressly labeled "overprotective," beg for re-evaluation now. This is especially true in the areas of limitations on use cases; technical and definitional rules that prohibit most UWB emission types; imaging systems definitions; prohibitions on most outdoor fixed applications; vehicular applications, generic materials sensing systems, location tracking applications, and surveillance applications.

II. Virtually All UWB Devices Require Waivers in Order to Obtain Grants of Equipment Authorization Under the Current Rules Structure.

7. Perhaps the most notable evidence of the need to revisit UWB technical rules now is the large number of waivers that have been and continue to be issued in order to bring a UWB device to the United States marketplace. Admittedly, the rather large body of waiver proceedings that the Commission has processed in the last two decades informs the record as to the virtual lack of interference attributable to UWB devices, and it illustrates that the Commission, in the main, has been willing to grant waivers for UWB devices and systems in certain categories. It is nonetheless readily apparent that the Commission is in the inefficient position of having to regulate UWB in the United States largely by waiver rather than by revisiting and replacing the current, conservative and limiting rules now in place with those rules that will actually facilitate the deployment of the technology while protecting incumbent services from interference. [10]Virtually all UWB devices approved for marketing and sale in the United States to date have been pursuant to *rule waivers*. The disadvantages of regulating by waiver include (1) delays in

[10] There is another "work-around" in the present Part 15 rules that has been used by some manufacturers otherwise disaccommodated by the UWB rules in Subpart F, but it is of very limited value in facilitating the development of spectrum-efficient UWB products in the United States. Section 15.250, contained among the Radiated Emission Limits and Additional Provisions segment of Subpart C of Part 15, permits operation of wideband systems within the band 5925-7250 MHz. There are numerous reasons why this is not in any sense a substitute for the proposed UWB rule revisions in Subpart F. First, Section 15.250 permits wideband operation only in the band 5925-7250 MHz. This, although necessary under the current scheme of regulation for some manufacturers, is far too limiting to provide for the advancement of a wide range of UWB products and use cases. Second, the band 5925-7125 MHz is now proposed in ET Docket No. 18-295 for additional widespread unlicensed operation without any protections being offered for incumbent UWB or other incumbent wideband devices and systems. Third, the use cases permitted for wideband devices permitted by Section 15.250 are very limited, as they are with UWB devices operating pursuant to Subpart F now: all fixed outdoor infrastructure, any aeronautical applications, and some consumer products are prohibited. Fourth, Section 15.250 applies the same testing procedure to devices subject to that Section that makes it very difficult for UWB devices to comply with the minimum bandwidth definition in Subpart F: Subsection 15.250(b) requires transmitters that employ frequency hopping, stepped frequency or similar modulation types to measure the −10 dB minimum bandwidth required in that Section to be made with the frequency hop or step function disabled. This is unnecessary in order to preclude interference (see *infra*, paragraph 34 and footnote 19). Though some UWB device manufacturers can, by virtue of Section 15.250, work around the Subpart F rules proposed to be modified hereunder without a rule waiver, that rule section is insufficient to accommodate current and future development of UWB technology in the United States. It is not a substitute for revision of the Subpart F UWB rules.

getting a product to market (typically12-24 months)[11]; (2) high legal and engineering expenses for manufacturers; (3) unpredictability as to outcome; and (4) an arbitrary, and somewhat inconsistent series of permitted and non-permitted devices. A product should not be permitted or prohibited based on whether or not the manufacturer can suffer the risk, delay and expense of a rule waiver proceeding each time it has a new or even a modified UWB device. An overhaul of the UWB rules that eliminates unnecessary restrictions and distinctions, and which allows certification and marketing of any UWB device that presents no realistic threat of interference would be far better from the perspective of the regulated manufacturing industry, which needs certainty as to their regulatory obligations.

8. On July 8, 1999, prior to the February, 2002 *First Report and Order* that adopted the present UWB rules, the Office of Engineering and Technology, on delegated authority granted waivers of certain Part 15 rules to three companies: Time Domain Corporation; U.S. Radar Inc.; and Zircon Corporation. These waivers allowed the limited marketing of UWB devices, subject to certain conditions. The Commission's premise was that UWB technology has unique attributes that could lead to a variety of new, beneficial uses that would serve the public interest. The conditional waivers granted to Time Domain, U.S. Radar and Zircon would, the Commission said, help in assessing the impact of UWB devices on the RF environment prior to adoption of FCC rules permitting some UWB operation. The waiver granted to U.S. Radar allowed it to market a radar system to detect buried objects such as plastic gas pipes or reveal hidden flaws in roads, bridges, or airport runways. The waiver granted to Time Domain allowed it to supply police departments with a communications system that would provide law

[11] See, e.g. Multiband OFDM Alliance waiver (2005); UltraVision Security Systems, Inc. (2008); Curtiss-Wright Controls Inc. (GPR Device Waiver, 2012); and Autoliv ASP, Inc. and Caterpillar, Inc. (UWB Vehicular Radar Waiver, 2013).

enforcement officers with a means of covert communication and to provide radar systems that would enable fire and rescue personnel to determine the location of persons inside damaged, burning, or smoke filled buildings. Zircon's waiver allowed it to supply a radar system that was capable of detecting objects, such as electrical wiring conduit, water pipes, and gas lines, behind walls and other surfaces. The three waivers, for different applications, were granted together.

9. Because the bands used by these devices included several frequency bands allocated to the U.S. Government, these waiver requests were coordinated with NTIA. NTIA informed the Commission, by letter dated June 15, 1999 that the waivers could be granted with conditions that, among other things limited distribution of the devices and required that records be maintained for all users to whom the three companies sell, lease or otherwise distribute UWB equipment. NTIA required that the equipment to be sold by each company be certified under the equipment authorization process. If harmful interference was caused or if the Commission adopted rules prohibiting them, then the company was to stop manufacturing or selling the products. All sales had to be documented so as to permit recovery of the devices sold later in case of interference. Special procedures were stated for coordination of channel use. Operation of the devices was generally prohibited near airports, GPS facilities or SARSAT, NOAA or radioastronomy facilities. All devices required manual operation through proximity switches, etc., and no aeronautical operation was permitted.

10. There were waiver conditions specific to the devices as well. For the U.S. Radar waiver, the term was four years, during which the applicant could market and sell its SPRscan GPR product. The limit on sales per year was 25 for this device. The signal had to be directed toward the ground at all times, and the waveform peak to average ratio was 30 dB. For the Time Domain device, the same 4-year term was as specified, but all told, 2500 units could be sold each

year of the waiver period. Eligibles were limited to police and fire departments and users of Part 90 public safety frequencies. The device waveform peak-to-average ratio was limited to 23 dB for communications systems and 26 dB for radar systems. For the Zircon device, the Commission allowed the marketing of 5000 systems used for through-wall imaging radar systems in construction environments provided that they meet certain average field strength limits. For example, on frequencies above 1 GHz, the limit was 63 microvolts per meter average at 3 meters, measured in 1 MHz. For bands between 960 MHz and 1 GHz, the limit was 63 microvolts per meter quasi-peak at 3 meters, measured in 100 kHz. The device waveform was 23 dB.

11. The Commission rules that were waived at the time, prior to the adoption of the UWB rules in Part 15, were Section 15.205(a), which specifies that only spurious emissions may be placed in certain designated restricted frequency bands of operation; and Sections 15.31 and 15.35 which require the application of a pulse desensitization correction factor when performing certain measurements below 1000 MHz. In announcing the grant of the waivers, the Commission said that the three waivers in no way prejudged any action that the Commission may take regarding UWB devices in the then-pending ET Docket 98-153. Nor should they be deemed in any way to prejudge NTIA's consideration of the issues involving the operation of UWB devices in any inquiry or rule making proceeding undertaken by the Commission. In this regard, NTIA requested that additional waivers to permit the marketing of UWB devices that emit radio frequency energy in the U.S. Government restricted bands be *extremely limited* until further analyses and measurements were completed and a regulatory framework developed.

12. After The Commission issued the UWB rules in February of 2002, it issued an Order (DA 02-1658, released July 12, 2002 in Docket 98-153) granting a “blanket waiver” to the

manufacturers of existing GPR and wall-imaging products authorized by experimental license or waiver prior to July 15, 2002 so as to permit prior users of those devices to keep using them. This was based, said the Commission, *on the absence of reported harmful interference*, and because of the public safety benefits resulting from the use of GPRs and wall imaging systems. The blanket waiver, however, was limited to *those two types of UWB devices*. It refused to afford the same blanket waiver to UWB surveillance systems, through-wall imaging devices or medical imaging systems because of a lack of experience with them. The same order encouraged those entities which felt disenfranchised by the UWB rules, including GPR or wall imaging device manufacturers, to seek waivers.

13. The conditions under which GPR and wall imaging manufacturers were entitled to the blanket waiver included the following:

> The operator shall follow the coordination procedures specified in 47 C.F.R. § 15.525. Coordination of each individual usage is not required. Instead, the coordination information shall describe the general areas in which the equipment is to be operated. This could consist of the count(y)(ies) of operation or even the state(s) of operation. We expect NTIA to notify the operator, through us, of any critical locations within these areas, as described in 47 C.F.R. § 15.525(e). Subsequent changes in operational areas will require the filing of a new transmission location following the procedures in 47 C.F.R. § 15.525 but will not affect the waiver status of the equipment described in the prior submission.
> In lieu of an FCC ID number, the users of GPRs and wall imaging systems purchased before July 15, 2002, shall provide us with a description of their equipment when filing for coordination. That description shall include, as a minimum, all identifying nomenclature on the product, such as the brand name and model, along with the frequency at which the GPR or wall imaging system operates. To the extent they are available, the operator shall provide emission characteristics described in 47 C.F.R. Part 15 Subpart F, as based on the measurement procedures described in the *Order*. We are not requiring equipment operators to have these emission characteristics measured. However, these emission characteristics may be used to calculate safety zones in the coordination process and, if not available, may result in increased safety zone areas.
> The operator shall supply the purchase date of the GPR or wall imaging system. An approximate date is acceptable if an exact date is not available. The GPR or wall imaging system must have been purchased by the operator prior to July 15, 2002, the

> effective date of the new UWB regulations, in order to qualify under this registration and waiver provision.

As far as can be determined, this blanket waiver is still in effect and these procedures are still followed for GPR and wall imaging systems, but not for through-wall imaging systems.

14. In June of 2002, a UWB start-up, XtremeSpectrum, introduced the first UWB device under the new rules for wireless connectivity applications using its direct sequence-UWB (DS-UWB) technology. XtremeSpectrum was acquired by Motorola in 2003 and later became the Ultra-Wideband operation of Freescale Semiconductor. In 2004, Freescale received Commission certification for the first UWB device for wireless communications applications under the UWB rules. The 110 Mbps device was manufactured and made commercially available. However, at the time of the UWB Report and Order in 2002, Multiband Orthogonal Frequency Division Multiplexing (MB-OFDM) had not been developed. In 2004, the Multiband OFDM Alliance filed a waiver request to allow this UWB application to be measured using different procedures than were specifically stated in the 2002 rules.

15. Under the original rules, UWB devices were required to be tested under full power, even if the devices themselves had "gating" or power-saving technology built in. MB-OFDM is a frequency-hopping technology, and therefore turns on and off frequently. The frequent bursts of power required to hop from one band to another exceed the Commission's -41 dBm/MHz power limit when measured in an always-on fashion. MB-OFDM specifications showed that this technology hopped an average of three times in a given transmission cycle, compromising performance when it tried to meet the FCC emission testing. The waiver request asked that the measurement for compliance be done only for the actual time transmitting, not the aggregate power of an always-on system. DS-UWB was also subject to the always-on requirements for

measurement. However, because DS-UWB transmits longer, continuous signals, it easily met the emission criteria while still delivering 110 Mbps at a range of 10 meters.

16. The Commission granted the MBOA waiver in March of 2005. In its *Order*, the Commission said that it was waiving the existing measurement procedure, permitting emissions from UWB transmitters to be determined with the transmitter operating "normally." The Commission concluded that this would not result in increased harmful interference to licensed radio operations. *This waiver applied only to indoor or handheld UWB devices*. Further, UWB devices utilizing this waiver could not operate within the 5030-5650 MHz band used for aircraft landing systems and for weather radars. A decision to permit this waiver to apply to UWB devices that operate within the 5030-5650 MHz band was to be made upon the completion of the interference investigation performed by the Institute for Telecommunication Sciences. The waiver was said to be effective until the Commission finalized a rulemaking proceeding dealing with the UWB measurement issues. The grant of this UWB waiver effectively removed the previous transmit power penalties for both frequency-hopping and gated UWB technologies. However, the ability of different UWB technologies to benefit from the new waiver provisions still depended greatly on a system design that can both leverage the benefits of UWB operation and effectively use gating or hopping to improve system performance. Under the rules, the -41 dBm/MHz power level had to be measured in always-on mode. After the waiver, only average power had to be measured; systems were then allowed to burst and then sit quiet when measuring the -41 dBm/MHz power limit.

17. Thus, the Commission allowed measurements to account for the time averaging during the time period in which the UWB emitter is not transmitting. In reaching its decision, the Commission recognized that the interference aspects of a transmitter employing frequency

hopping, stepped frequency modulation, or gating are quite similar, as viewed by a receiver, in that transmitters using these burst formats appear to the receiver to emit for a short period of time followed by a quiet period. The Commission concluded that any requirement to stop the frequency hopping, band sequencing, or system gating serves only to add another unnecessary level of limitations to already overly strict UWB standards. Yet, the rules were not reexamined. Instead, the waiver process became the norm.

18. On November 20, 2008, the Commission granted in part a request submitted by UltraVision Security Systems, Inc. (UltraVision) for a waiver of the UWB rules to allow limited marketing of its UltraSensor UWB surveillance systems. UltraSensor is a UWB fixed radar surveillance system designed to operate in the spectrum region below 960 MHz, from 80 MHz to 600 MHz, and is intended to provide warning of intruders to sites with strategic or commercial interests. Each system consists of six to ten unlicensed transmitters buried 15-20 centimeters (6-8 inches) underground, below pavement or lawn turf, about every 20 meters (65 feet) around the site to be protected. The system tracks the location, velocity and mass of an intruder and can be programmed to ignore small animals, *e.g.*, birds and dogs, but to respond only to pedestrians and vehicles; or to respond only to vehicles above a certain size or speed. The waiver proceeding was initiated in 2006 and resulted in a Docket proceeding (06-195). UltraVision requested a waiver of the permitted operating frequency range and sought to permit users in Sections 15.511(a) and (b) of the Rules [12] to allow it to market up to 350 installations of the UltraSensor system over a two year period. The Commission agreed to waive those rules to permit the UltraSensor surveillance system to operate in the 80-600 MHz frequency band and to allow UltraVision to market the systems to any entity eligible for licensing under Part 90 of the rules. It did, however,

[12] This rule deals with surveillance systems between 1.990 GHz and 10.6 GHz, and limits operation to fixed surveillance systems operated by law enforcement, fire or emergency rescue organizations or by manufacturers licensees, petroleum licensees or power licensees as defined in § 90.7 of the Land Mobile Rules.

impose specific operational and technical conditions on the UltraSensor systems to ensure that authorized spectrum users are protected from harmful interference, including maintaining the requirement that operators of these surveillance systems comply with the Commission's very extensive coordination requirement for UWB devices in Section 15.511(b)(2) of the Rules. The Commission denied that part of UltraVision's request which asked that UltraVision be allowed to maintain a list of installations in lieu of complying with the prior coordination requirements. The waiver was found to be in the public interest because it would permit the operation of systems capable of providing protection from undesired intrusions to secured facilities, without increasing the risk of harmful interference to authorized services.

19. In November of 2010, Bosch applied for a waiver of Section 15.503(h) of the FCC's rules for its Wallscanner D-tect 150 Professional device and for functionally identical versions of that device, in order to permit Bosch to import and market the device upon receiving a grant of equipment authorization. This waiver was granted in May of 2011, six months after applying for the waiver. The waiver was conditioned on compliance with all other requirements of the Commission's rules, including the technical and operational requirements for unlicensed ultra-wideband imaging systems in Section 15.509 of the Rules. Grant of the waiver was attributed to the utility of the device and its applications in building construction, as well as inspection and maintenance of buildings and infrastructure in the United States. There was also a finding that it would have minimal interference potential due to the fact that the market for the device did not include general consumers; it was intended for and limited to use by construction professionals. The fact that the Wallscanner device was already in widespread use in Europe, Canada, and Asia and the fact that it met all technical requirements of the Commission's Part 15 rules applicable to UWB devices were cited as important factors.

20. The waiver in that case was merely one of definition: Section 15.503(h) of the Rules defines a "wall imaging system" as a "field disturbance sensor that is designed to detect the location of objects … or to determine the physical properties within the 'wall' [which is a] physical structure that is dense enough and thick enough to absorb the majority of the signal transmitted by the imaging system." The rule excludes "products such as 'stud locators' that are designed to locate objects behind… walls that are not capable of absorbing the transmitted signal." Bosch candidly noted that not every wall or other structure scanned by the Wallscanner would be dense and thick enough to absorb the entirety of the transmitted radio signal; therefore, the Wallscanner would not necessarily meet that part of the definition. Furthermore, the Wallscanner included as one of its operating modes a "stud locator" function which would preclude its classification as a wall imaging system. Had the Wallscanner been classified as a "through-wall imaging system," its intended use would not comply with Section 15.510(b) of FCC rules, which restricts the use of such systems to law enforcement, emergency rescue or fire-fighting organizations that are under the authority of a local or state government, thus strictly limiting the application of through-wall imaging systems to public safety functions. Ultimately, because the Wallscanner was not a consumer device and because it would operate well below the maximum radiated emission level in Section 15.509, which is an EIRP of -41.3 dBm/MHz in the band 3,100-10,600 MHz, the waiver was found to be acceptable. Since that time, however, successor versions of the device would have been subject to a repeat of the waiver request process.

21. In January of 2012, the Commission granted a waiver to Curtiss-Wright Controls Inc. of Sections 15.503(d) and 15.521(d) of the UWB rules for its ground penetrating radar

System called "3D-Radar." Curtiss-Wright had requested this waiver in June of 2010, a year and a half prior to the grant. This GPR device detects buried objects, changes in material, and cracks in ground or in other subsurface structures and is typically used in the maintenance of highways and bridge infrastructure in the United States. This too was in effect a definitional waiver. Section 15.503(d) of the Rules specifies the minimum operational bandwidth of an UWB transmitter. The measurement procedure for determining minimum bandwidth for UWB devices is Section 15.521(d). The waiver required grant of equipment authorization for this GPR and compliance with all other technical and operational requirements for unlicensed UWB GPR devices. Like the Bosch Wallscanner, the device was found to be useful for improvement of the safety of transportation infrastructure without increasing the potential for interference to authorized radio services.

22. The definition of a UWB device is one which has a fractional bandwidth equal to or greater than 0.20 or an UWB bandwidth equal to or greater than 500 megahertz, regardless of the fractional bandwidth. Clearly, the rules envision that UWB devices employ pulse modulation technologies. When it adopted the UWB rules, the Commission said that UWB devices could use other modulation types *if they meet the minimum bandwidth requirements* and that this requirement was intended to avoid having devices designed for the "restricted bands" if they did not need to operate in those bands. The Commission also said that "it was unlikely" that swept frequency, stepped frequency, or frequency hopping systems would comply with the minimum bandwidth requirement because, unlike UWB systems, the emissions for these other systems were typically measured with the sweep/step/hopping function stopped. Section 15.521(d) of the Commission's rules sets forth the measurement procedures for UWB devices to demonstrate compliance with applicable emission limits. For emissions above 960 MHz, this rule requires

that, if pulse gating is used and the transmitter is stopped for longer intervals than the nominal pulse repetition interval, measurements are made with the pulse train gated on. The Commission said it would also "consider alternate measurement procedures." This signaled an intention to use a waiver procedure for authorizing, if not all, then the vast majority of UWB devices. Curtiss-Wright said that its 3D-Radar system operated between 140 MHz and 3 GHz using stepped frequency modulation to achieve performance characteristics of deep signal penetration, high resolution imaging, and fast survey speeds.

23. The 3D-Radar uses an array of closely spaced antennas that transmit sequentially over a wide band of spectrum and gathers a variety of data from underground structures in a single pass. The system transmits over 1,431 frequencies in 2-megahertz steps between 140 MHz and 3 GHz with a scan/cycle rate of approximately 2.86 milliseconds. Its stepped-frequency technique using a wide bandwidth antenna array allows it to travel at high speeds and eliminate the need for multiple passes. This results in less RF energy being transmitted at any one location, thereby minimizing risk of potential interference to authorized services. The fact that it had already been certified for use in the European Union was a large factor in the waiver grant decision. Because the 3D-Radar system did not satisfy the definitional requirement of Section 15.503(d) that an UWB transmitter "*at any point in time*" has a fractional bandwidth equal to or greater than 0.20 or has an UWB bandwidth equal to or greater than 500 megahertz, a waiver was necessary. It also required a waiver of the Section 15.521(d) measurement procedure requirement 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. There were supporting comments filed by Bosch and by the Federal Railroad Administration, but opposition from the GPS Industry Council, concerned about interference. NTIA had already approved the device for

use by the U.S. Department of Transportation. There was a discussion about notching of frequencies but Curtiss-Wright said that a notching requirement would create unclear images and the Commission's rules did not require such. Although the device used stepped frequency modulation, the Commission was persuaded that this device was similar in all other respects to normal GPRs and that most of the energy would be radiated into the ground. The Commission noted the complete absence of interference complaints from GPRs authorized by blanket waivers or experimental authorizations. Furthermore, it was found to be a useful tool for monitoring transportation, and especially railroad, infrastructure and insuring safety of travel. The waiver in this case was granted subject to the following conditions:

- It must be certified by the Commission, and operate with stepped frequency modulation in 2 megahertz steps between 140 MHz and 3 GHz with a scan/cycle rate of approximately 3 milliseconds. The system may not use any single frequency longer than 2 microseconds in any 3 millisecond period of time.
- Measurements of emissions must be conducted with the stepping function active.
- The device cannot be sold in any hand-held configuration.
- It must comply with all other technical and operational requirements applicable to UWB GPR devices under Part 15, Subpart F of the Commission's rules.
- It must implement frequency notching to avoid placing intentional transmissions in the bands 608-614 MHz, 1400-1427 MHz, 1660.5-1668.4 MHz, and 2690-2700 MHz.

The Commission, in 2013, modified the above waiver conditions at Curtiss-Wright's request, so as to permit use of stepped frequency modulation in 2, 10, or 20 megahertz steps, and by changing the original pulse width requirements to a duty cycle requirement.

24. On December 30, 2013, the Commission granted a temporary waiver of the UWB emissions limits in Section 15.515(c) of the FCC's rules. This waiver permitted Autoliv to continue to manufacture and market to Caterpillar until December 31, 2014 and for Caterpillar to import

until that same date Autoliv's C4 vehicular radars. These radars complied with the existing emissions limits of Section 15.515(c), but did not comply with the limits that were phased in on January 1, 2014 under that same rule. The Commission granted the waiver to permit the continued use of Caterpillar vehicles, which couldn't be operated safely without effective radar systems, due to their size and shape and their operating environment (often in mines and in narrow passageways). Accordingly, Caterpillar needed a temporary waiver in order to continue to equip the subject vehicles with the C4 radar systems through 2014, after which systems using compliant radars became available from Autoliv. About the emission limits, the Commission said that they have evolved over time, with one standard applicable to equipment manufactured after January 1, 2005, another standard applicable to equipment manufactured after January 1, 2010, and yet another standard applicable to equipment manufactured after January 1, 2014. The Commission's principal concern in adopting this rule and set of phased-in limits was the cumulative interference to passive sensing systems operating in the 23.6 to 24.0 GHz band on low earth orbiting satellites, including meteorological satellites, caused by "potentially tens of thousands of transportation vehicles employing these radar devices." Multiple factors, most notably the low density of vehicles, led the Commission to conclude that the impact of this waiver on the potentially affected satellites was likely to be negligible.

25. The Commission is still considering a January 16, 2018 request from Sensible Medical Innovations Ltd. for a waiver of Sections 15.31(c), 15.503(d), 15.513(a), 15.521(d), and 15.525 of the Commission's rules to allow the marketing and operation of a stepped frequency UWB medical imaging and diagnostic device that can provide accurate lung fluid measurements for congestive heart failure patients in a non-invasive way. The device operates over the frequency range of 1005-1709 MHz. Sensible needs a Section 15.503(d) waiver of the definition

of a UWB transmitter as an intentional radiator that, at any point in time, has a fractional bandwidth equal to or greater than 0.20, or that has a UWB bandwidth equal to or greater than 500 megahertz, regardless of the fractional bandwidth. Its product would not satisfy this definition because it steps a continuous wave signal through its operating frequency range, resulting in a fractional bandwidth of less than 0.20 and individual transmissions of less than 500 megahertz at any point in time. It also needs a Section 15.513(a) waiver. That rule requires that the UWB bandwidth of a medical imaging system be contained between 3100 MHz and 10,600 MHz and in order to function, the Sensible device must operate in the range of 1005 to 1709 MHz, because accurate lung fluid detection requires frequencies that can penetrate the body.

26. Furthermore, the testing procedures in Section 15.521(d) require that when pulse gating is employed and the transmitter is quiescent for intervals that are long compared to the nominal pulse repetition interval, measurements must be made with the pulse train gated on. Section 15.31(c) requires that for swept frequency equipment, measurements must be made with the frequency sweep stopped. Sensible argued that any requirement to stop frequency hopping, band sequencing or system gating during testing adds an unnecessary level of conservatism to already stringent UWB standards. Waivers of Sections 15.31(c) and 15.521(d) to allow measurements to be performed with the frequency stepping active were also requested. Finally, Section 15.521(d) of the UWB rules also requires that measurements of emissions above 960 MHz be made with a root mean square (RMS) average detector over a 1 MHz resolution bandwidth, with an averaging time of one millisecond or less. Because Sensible's device employs a four-millisecond dwell time on each frequency, a waiver of this section is necessary as well, even though the change is not likely to result in harmful interference to other services due to the infrequent, intermittent use of the device in indoor locations where signals are directed

towards a patient's body cavity. Finally, Section 15.525 requires that users of UWB imaging devices coordinate the deployment of their systems with NTIA through the Commission. Sensible claims that this requirement is impractical for a body-worn device that will operate intermittently indoors, and it requests a waiver of this rule. This proceeding[13] is still open.

27. On March 14, 2018 the Commission granted [14] a waiver to Proceq USA, Inc. filed September 11, 2017. Proceq filed a waiver request to allow the marketing and operation of a fast-stepping continuous-wave ground penetrating radar device that provides increased performance in determining the safety and stability of materials. The device uses stepped frequency continuous-wave (CW) modulation to suppress RF interference from Wi-Fi and GSM sources which can impede the performance of conventional GPR devices. The device required a waiver of the same UWB definition and measurement procedure rules that inhibit other UWB manufacturers. The Section 15.503(d) "at any point in time UWB bandwidth definition requirement required waiver because the Proceq device steps a narrow signal through the 200 to 4000 MHz range. Each of these individual transmissions is less than 500 megahertz in bandwidth "at any point in time" even though the device has a total bandwidth that exceeds 500 megahertz.[15]

28. In granting the Proceq waiver, the Commission noted that 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. Further, it said that the primary difference between the Proceq device and other UWB

[13] See Docket No. 18-39; *Office of Engineering and Technology Seeks Comment on Sensible Medical Innovations Ltd.'s Request for Waiver of Part 15 Ultra-Wideband Rules for a Medical Imaging System*, DA 18-131, released February 9, 2018.
[14] See, DA 18-251, released March 14, 2018.
[15] The Commission noted in the proceeding that "[s]tepped and swept frequency devices like Proceq's have a difficult time complying with our rules because the large bandwidth is achieved by stepping or sweeping a narrow signal through the broader frequency range, and therefore won't be instantaneously wide enough to meet the rules' specific requirements."

GPR devices provided for in the rules is that the Proceq GPR device uses stepped frequency CW modulation (*i.e.*, an array of closely spaced transmitting/receiving antennas that transmit sequentially over a large band of spectrum) to gather all the needed data. The Commission held that this modulation scheme is functionally equivalent to other types of UWB GPR devices in that it uses transient-like signals spread across a wide bandwidth, and therefore the risk of interference from the Proceq GPR device is no greater than that from other UWB GPR devices. The Proceq GPR device also required Section 15.31(c) and Section 15.521(d) waivers of measurement standards. Specifically, the Commission waived the requirement that swept frequency equipment measurements be made with the frequency sweep stopped; and the requirement 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. The Commission held that 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, and so demonstrating compliance with the UWB GPR emission limits with the stepping function active will not undermine the purpose of the rule. To ensure that the Proceq GPR device does not emit in any individual 10 MHz, 20 MHz, or 40 MHz narrow band continuously, the Commission did condition the waiver on a limited dwell time during any step to less than or equal to 0.04 percent of the device's minimum scan/cycle rate.

29. It is apparent that the Commission is regulating UWB by waiver, rather than by a set of rules that appropriately regulate the interference potential of these devices. The Commission's failure to make any permanent modifications to the UWB rules, or even to propose such over a sixteen-year period, has necessitated this continuous series of waivers for such products. These were sought at notable expense to the importers and manufacturers of such devices, and the

procedure has resulted in substantial delays in bringing new UWB devices to the marketplace. The obligation has ill-served the consumers and users of such devices and the ability of business entities and others to compete in the development and marketing of UWB products in the United States. Businesses are unwilling to invest in the research and development necessary to bring new UWB products to the marketplace because of the risk that the devices won't be approved, or will be delayed for half a year or much longer. Regulation by waiver is an inadequate substitute for flexible rules which should permit many UWB products to become certified for marketing and sale in the United States as a matter of course. Appropriate rule changes are proposed in the attached Appendix. While the Commission is willing to grant waivers on an irregular basis, that procedure involves placing them on a public notice; taking public comment in response to them; and staff analysis of the waiver request (often, if not always, in consultation with NTIA: a process which does not permit public input). The waiver procedure takes well more than a year in many cases. Given the expense and delay inherent in the process, and the relatively short life cycle of many manufactured electronic products, few UWB devices are available here. By contrast, large numbers of such products are in successful use in Europe and Asia and interference potential is successfully managed through more flexible rules which are under regular review and discussion.

III. The Rule Changes Suggested Herein Will Reduce "Regulation by Waiver" for UWB Products; Permit Effective Competition in the United States; and Bring New, Useful Products to the Marketplace Without Increasing Interference Potential to Authorized Radio Services.

(A) Definition of Minimum Bandwidth

30. Principal among the UWB rules necessary for modification are the 2002 rules governing UWB minimum bandwidth. The Commission had earlier proposed to define a UWB device as any device where the fractional bandwidth is greater than 0.25 or occupies 1.5 GHz or

more of spectrum.[16] The formula proposed for calculating fractional bandwidth was $2(f_H-f_L)/(f_H+f_L)$ where f_H is the upper frequency of the –10 dB emission point and f_L is the lower frequency of the –10 dB emission point. The center frequency of the transmission was defined as the average of the upper and lower –10 dB points, i.e., $(f_H+f_L)/2$. The Commission proposed to base its modified definition of an UWB device on –10 dB bandwidth.

31. Those who filed comments typically urged that the definition of UWB should either be a fractional bandwidth or a minimum emission bandwidth.[17] There was no consensus, however, on the specific values that should be applied for a device to be defined as UWB. The comments also disagreed about limiting the modulation to pulsed modulation, and requiring that the bandwidth be directly related to the narrow pulse width instead of the data rate. Bosch's position at the time was that the definition of UWB should be based solely on bandwidth using the –10 dB emission points. [18] Bosch stated that the –20 dB emission points were too near the noise floor to be measured reliably. Bosch also noted that the –20 dB emission points would be ambiguous, as such points appear on both the fundamental lobe and the side lobes. Bosch argued that basing the definition of UWB on the use of a narrow pulse width to achieve a wide emission bandwidth could impede the development of novel pulse or modulation schemes, including high-speed data systems.

32. In the 2002 *First Report and Order* in the docket proceeding, the Commission decided to use the –10 dB emission points to determine the bandwidth and the center frequency of the UWB emission. It agreed with Bosch and others that the –20 dB emission points could be

[16] Under that proposed definition of an UWB device, the 1.5 GHz maximum bandwidth limit would have applied only where the center frequency was greater than 6 GHz.
[17] The Commission uses the term "minimum bandwidth" to refer to the bandwidth above which a product qualifies as a UWB device regardless of its fractional bandwidth.
[18] Bosch's proposal would have been similar to the ITU definition of UWB, as per Recommendation ITU-R SM.1755.

so near the noise floor that making accurate measurements would be difficult or impractical. It also decided that the minimum required fractional bandwidth should be reduced given that the use of the –10 dB bandwidth measurement points will result in a smaller measured bandwidth. So the Commission decided that the –10 dB fractional bandwidth should be 0.20, and that the minimum bandwidth limit, originally proposed to be 1.5 gigahertz, would instead be 500 megahertz for UWB devices.[19] The Commission said that the minimum bandwidth limit of 500 megahertz should accommodate "most of the proponents in this proceeding." The Commission specifically refused to eliminate all restrictions on fractional bandwidth and minimum bandwidth, because without the limit, devices could be designed to operate in restricted bands without any need to do so.

33. The Commission agreed with Bosch that transmission systems should not be precluded from the UWB definition simply because the bandwidth of the emission is due to a high speed data rate instead of the width of the pulse or impulse. Therefore, the Commission noted, ***"as long as the transmission system complies with the fractional bandwidth or minimum bandwidth requirements at all times during its transmission, we agree that it should be permitted to operate under the UWB regulations."*** This requirement, that the minimum bandwidth must be met "at all times," unless flexibly applied, precludes the use of essentially all modulation schemes, except a continuous-wave signal of at least 500 MHz bandwidth. Pulsed emissions, frequency-hopped emissions, and swept frequency (*e.g.*, FMCW) systems are all, strictly speaking, precluded by this requirement because they do not "at all times during its transmission" have a bandwidth of that magnitude.

[19] UWB devices would be required to have a –10 dB fractional bandwidth of at least 0.20 or a –10 dB bandwidth of at least 500 MHz. The effect of this change is that UWB systems with a center frequency greater than 2.5 GHz need to have a –10 dB bandwidth of at least 500 megahertz while UWB systems operating with a center frequency below 2.5 GHz need to have a fractional bandwidth of at least 0.20.

34. Nevertheless, the definition of UWB relative to minimum bandwidth requirements adopted in the UWB *First Report and Order* is unchanged to the present time. It reads as follows:

> Section 15.503 Definitions.
>
> (a) UWB Bandwidth. For the purpose of this subpart, the UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna. The upper boundary is designated f_H and the lower boundary is designated f_L. The frequency at which the highest radiated emission occurs is designated f_M.
>
> (b) Center frequency. The center frequency, f_C, equals $(f_H + f_L)/2$.
>
> (c) Fractional bandwidth. The fractional bandwidth equals $2(f_H - f_L)/ (f_H + f_L)$.
>
> (d) Ultra-wideband (UWB) transmitter. An intentional radiator that, **at any point in time**, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth.
>
> (emphasis added)

The definition of UWB in Section 15.503(d) requires without exception, therefore, that the minimum bandwidth requirement must be achieved *at all times during the transmission*, regardless of modulation or emission type. Current measurement procedures require that measurements of swept frequency devices be made with the frequency sweep stopped.[20] The sweep is stopped because no measurement procedures have been proposed or established for swept frequency devices, nor have the interference aspects of swept frequency devices been evaluated based on the different measurement results that would be obtained from measurements taken with the sweep active.[21] Similarly, measurements on a stepped frequency or frequency hopping modulated system are performed with the stepping sequence or frequency hop stopped.

[20] 47 C.F.R. §15.31(c).

[21] However, experience with waivers of Section 15.31 has led the Commission to conclude that measurements with the sweep, step or hopping function active does not lead to increases in interference potential.

With the sweep, step function or hopping stopped, it is unlikely that swept frequency (linear FM or FMCW) or stepped frequency modulated emissions would comply with the fractional bandwidth or minimum bandwidth requirements. The Commission admitted that it is "unlikely that frequency hopping systems would comply unless an extremely wide bandwidth hopping channel is employed."

35. In 2003, the Commission issued a *Memorandum Opinion and Order and Further Notice of Proposed Rule Making* in the UWB docket, which made no change in the minimum bandwidth requirement but did state: "The rules adopted in the *R&O* also permit UWB devices to comply with the minimum bandwidth requirement due to the use of a high speed data rate or the use of other modulation techniques instead of the width of the pulse or impulse signal."

36. Finally, in December of 2004, the Commission issued a *Second Report and Order and Second Memorandum Opinion and Order*, which addressed proposed changes in operational standards for unlicensed devices that may apply simply due to the bandwidth of the transmission system. The Commission said that its standards for unlicensed devices must reflect emission limits that reduce the potential for causing harmful interference to authorized radio services. The emission limits applied to UWB ensure a low probability of causing harmful interference, *and the minimum bandwidth requirement could have the opposite effect than what is intended: it could cause a manufacturer to design transmitters that occupy more bandwidth than is operationally necessary or transmitters that inject noise in order to increase the occupied bandwidth simply to permit operation under the UWB regulations. This would place greater energy in frequency bands where operation is not necessary for the system to function and increase the interference potential.* So, the Commission realized that a minimum bandwidth standard could be counterproductive to reducing the potential for harmful interference and it

proposed to eliminate the definition of an ultra-wideband transmitter in 47 C.F.R. § 15.503(d). The Commission recognized that it is the limit on emission levels (and particularly the limit on spectral power density) that primarily controls interference potential, not whether or not the minimum bandwidth is met "at all times." The Commission proposed to permit the operation of any transmission system, regardless of its bandwidth, as long as it complies with the standards for UWB operation set forth in Subpart F of 47 C.F.R. Part 15 and based the resolution bandwidth used for the peak power measurement to 10 percent of the -10 dB bandwidth of the emission. NTIA opposed eliminating the bandwidth requirements, stating that the supporting comments offered no technical support and expressed concern that such a change would permit operation in the restricted bands regardless of the bandwidth of the unlicensed emission.[22]

37. There were petitioners in favor of eliminating the minimum bandwidth requirement. The Commission accommodated them by amending the Part 15 rules applicable to peak power levels for unlicensed operation in the 5925-7250 MHz, 16.2-17.7 GHz and 22.0-29.0 GHz bands. However, the Commission said it found "no necessity at this time to eliminate the UWB minimum bandwidth requirements." It said that such changes "could be disruptive and could further delay the introduction of UWB devices" and that any operation in the restricted bands should be subject to the additional technical standards and operational parameters specified in the UWB regulations. So, it refused to change the minimum bandwidth requirements for UWB devices "until additional experience has been gained with this equipment."

[22] This concern was obviated in Europe, because the European Telecommunications Standards Institute (ETSI) and the industry evaluated the different kinds of possible UWB signals individually. If the measurement setup and equipment is chosen appropriately, UWB emissions could be measured correctly, such that all types of emissions can be compared with existing regulatory requirements (dBm/MHz mean or dBm/50MHz peak). The related ETSI measurement is identified as EN: 303 883. ETSI is currently updating EN 303 883. Now, a new EN 303 883-1 is planned, which will focus on transmitter measurements only. A specific UWB test setup will be specified to fulfill a correct result depending on the UWB signal characteristics and the averaging requirement limit in dBm/MHz averaged over 1 millisecond.

38. It would appear that the Commission recognized at the outset that its requirement that the minimum bandwidth of a UWB device must be achieved "at all times" during a transmission would impose limits on UWB deployment and preclude certain UWB products. What perhaps it did not realize was that the requirement, if strictly interpreted, would prohibit effectively all UWB devices, since none, including pulsed emission UWB devices, can meet this absolute restriction absent a waiver grant. The Commission's motive was clear: it was proceeding cautiously and intended at all costs to avoid interference in the Part 15 restricted bands. The rule, however, is unclear, and is completely preclusive, because a common-sense interpretation of it has not heretofore applied: that "at any point in time" means "during its normal operating mode." Absent such an interpretation, any UWB product that would not at all times during its transmit cycle, meet the minimum bandwidth requirement would require a waiver from the Commission. It is not reasonable to continue to preclude all frequency hopped UWB emissions below 10 GHz, nor all pulsed, stepped and swept (e.g. FMCW) emissions. Many UWB devices and systems now available are no longer pulse-based. Frequency-hopped spread spectrum (OFDM) systems are preferred for some applications. In normal operation, achieving a 500 MHz bandwidth is easily done. But in terms of achieving that minimum bandwidth, nothing can be measured in zero time: a maximum time should be included in the definition, perhaps a normal one millisecond, in which the minimum bandwidth must be generated. [23] The definitional limitation should be modified in any case so as to allow the minimum bandwidth to be achieved during the normal operating cycle of the device.

39. As to the measurement process for determining minimum bandwidth, there should not be a requirement to switch off the modulation during the test procedure. Section 15.31(c)

[23] In other words, the measurement time of the measurement receiver (such as a spectrum analyzer) during which the minimum bandwidth requirement must be met (e.g. one millisecond) should be specified in the rules. The requirement cannot be fulfilled in no time or during an unspecified time, but only within a certain time delta.

currently requires that measurements of swept frequency devices must be made with the frequency sweep stopped. Similarly, measurements on a stepped frequency or frequency hopping modulated system are performed with the stepping sequence or frequency hop stopped. With the sweep, step function or hopping stopped, it is highly unlikely that swept frequency (linear FM or FMCW) or stepped frequency modulated emissions would comply with the fractional bandwidth or minimum bandwidth requirements. For emissions such as frequency-hopped spread spectrum, where the stepping is the basis for generating a UWB signal, the basic modulation should not be switched off for measurement. [24] The current test requirements of Sections 15.31(c) and 15.521(d) of the Rules are optimized for pulse-based UWB signals only. To measure bandwidth for other types of UWB emissions correctly, there is a need to use different test configurations and methodologies. [25]

(b) The Definitions of "Imaging System" and "Surveillance System" Should Be Revised and Additional UWB Applications and Use Cases Permitted.

40. Section 15.503(e) narrowly defines "imaging systems." [26] It is suggested that the term should include material sensing devices more generically, so as to permit a wider range of useful industrial and commercial products which have negligible interference potential. For example, it is recommended that the United States should adopt the functional definitions enunciated in ECC

[24] Indeed, one regulatory alternative to testing with the modulation turned off is to prohibit UWB sensors or other devices which are capable of switching off the modulation or which could change to an operating mode in which the emission is less than 500 megahertz. Alternatively, a requirement could be implemented which would provide that in all modes of operation of the UWB device, the necessary or occupied bandwidth must be greater than 500 megahertz.

[25] It is notable that ETSI has prepared a specific measurement plan to measure all kinds of UWB signals in an accurate manner. See, ETSI EN 303 883 (V1.1.1): *Short Range Devices (SRD) using Ultra Wide Band (UWB) Measurement Techniques.*

[26] Section 15.503(e) currently reads as follows: "Imaging system. A general category consisting of ground penetrating radar systems, medical imaging systems, wall imaging systems through-wall imaging systems and surveillance systems. As used in this subpart, imaging systems do not include systems designed to detect the location of tags or systems used to transfer voice or data information."

Decision (07)01, as amended, which refers to "contact based" sensors and imaging devices[27], and "non-contact based" sensors and imaging devices.[28] To avoid interference to other users it is possible to change measurement technique regulations. For example, the existing test environment for ground probing devices (which is now sand pitch) should be changed to a generic test scenario in which UWB material sensors are radiated into the material to be evaluated. For the conformance test, the emissions outside this scenario should be measured. To describe such test methodologies, the Commission is properly referred to ETSI harmonized EN 302 065-4.[29] Surveillance systems could be interpreted as providing a radiodetermination function such as the detection of objects in free space. The International Radio Regulations, specifically ITU-R RR: 1.9, define radiodetermination as the "determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these parameters, by means of the propagation properties of radio waves." A more generalized definition for UWB surveillance system applications is in order. Within these more generic definitions should be included more flexible use-cases (independent of user categories, which do not by themselves avoid misuse). If the definitional regulations are not preclusive of new UWB applications, and if there are clear, yet flexible technical requirements (including the flexibility to utilize varied emissions types), this would provide better interference protection than defining who the eligible users of unlicensed devices are and excluding most use cases in the process. This is especially true where, as in the current rules, the definitional eligibility is not clearly

[27] With contact-based sensors and imaging devices, the UWB transmitter is switched on only when in direct contact with the material under investigation.
[28] With non-contact-based sensor and imaging devices, the UWB transmitter is switched on only when in close proximity with the investigated material and the UWB transmitter is directed into the direction of the material under investigation (e.g. manually, by using a proximity sensor or by mechanical design).
[29] ETSI EN 302 065-4: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 4: Material Sensing devices using UWB technology below 10,6 GHz".

defined. In the ECC paradigm for UWB regulation, mitigation factors in place are focused on protection of other in-band and out-of-band incumbents.

41. The applications and the benefits of UWB are potentially far wider than the limited definitions in the current rules permit. System opportunities include ranging, tracking, object classification, and low power consumption. The benefits of more flexible use cases can be realized with low or negligible regulatory impacts. UWB devices operate with very low radiation levels, low power spectral densities, and significant opportunities for spectrum sharing through overlays, due to the availability of numerous mitigation techniques such as limited duty cycles, limited radiation patterns and beam tilt requirements. UWB outdoor (mobile and fixed) applications for surveillance should be available generically, but with necessary interference mitigation restrictions. This point has been addressed within the ECC as well.[30] The following example outlines one possible application: Motion and presence detection in the field of home and building automation is a fast growing application sector. Current technologies such as passive infrared or continuous wave radar sensors have different drawbacks such as sensitive lenses, coarse recognition qualities or temperature dependencies. Ultra-wideband sensors can combine the advantages of different sensor technologies. These can be invisible where mounted behind non-metallic covers, allowing higher precision detection and distance measurements of moving objects. Such features make an UWB sensor outstanding for outdoor motion and presence detection. The basic technical configurations of this application could include (a) bandwidths up to 2.5 GHz within the 6 to 9 GHz range; (b) use of pulse-based sensors with a PRF of $\leq$ 4MHz; (c) mean power limits on the UWB signal; (d) location precision of 0.1 to 1 meter (in distance and object separation); a detection distance of between 15-18 meters; (e) a low duty cycle (LDC) parameter - typically less than1% (single transmission, T on-time: ~ 2ns); (f)

[30] See ETSI TR 103 314

an antenna gain of less than 4dBi; (g) a 90-degree horizontal and vertical pattern; and (h) an antenna tilted downward from the horizon, with an installation height of between 2-3 meters. This would allow motion detection to be active 24 hours per day with no appreciable interference potential at all.

42. For motion and presence detection applications, interference mitigation factors could be required: duty cycle restrictions, such as less than 1% with a transmission template (e.g. transmit on times of 2-5 nanoseconds; power restrictions for fixed applications such as -51.3 dBm/MHz (this is a typical level that could be assumed to be radiated through the walls from indoor applications, and 10dB is used in CEPT/ECC studies for indoor/outdoor effects); field strength limits over the horizon, assuming, for example, an installation height for fixed applications of greater than 10 meters AGL; antenna angle limits requiring down tilt; and as necessary, power restrictions. Options for "non-contact" based material sensing devices, imaging devices and surveillance radars include mechanical design features, such as required antenna directionality and beamwidth limitations to minimize emissions in directions which are not relevant for the application. Limitation of EIRP over the horizon or limitations on the total radiated power of the device in the main lobe of the directional antenna is a reasonable mitigation technique, as are EIRP limitations in azimuths outside the main lobe. Sensors could be permitted to transmit full power if the object for investigation or determination is in the "focus" area of the sensor, or if the UWB sensor is triggered by another sensor, as is the case with narrowband radars and infrared devices. An emission limit could take into account the shielding effect of the object or material being evaluated. A combination of these mitigation techniques should be implemented as necessary rather than to rely on unclear definitional or overly restrictive eligibility limitations, as do the current rules.

43. Other definitions in the current rules are inherently contradictory and should be revisited. For example, Subsection 15.503(h) defines wall imaging systems, which are field disturbance sensors used for the purpose of detecting the location of objects contained in a wall, but excludes "stud finders" for construction purposes. This classification makes no sense unless it can include stud finding functions of wall scanners. This matter is better dealt with by reference to "Building Material Analysis" (BMA) addressed in ETSI EN 30 065-4 which takes into account interference potential of radiated emissions behind walls being measured. By contrast, Subsection 15.503(j) addresses through-wall imaging systems intended to detect persons or objects behind a wall. Currently this use-case is very specifically limited to governmental uses, such as those of first responders. It is not a regulation intended to address industrial or commercial applications of wall imaging systems that might have some residual emission beyond the wall being evaluated. A more bright-line definition of use cases is important and easily achievable in order to avoid regulation by waiver.

44. Finally on the subject of definitions of UWB applications, there are doubtless missing use-cases or gaps in the rules which exclude potentially useful applications. It is respectfully requested that the Commission harmonize its Part 15 UWB rules with those in other countries. UWB lends itself to compatible spectrum overlays relative to incumbent narrowband applications, and therefore offers a spectrum-efficient solution for applications which are currently disaccommodated by the absence of narrowband spectrum availability. CEPT/ECC studies accommodate additional UWB applications that the Commission's rules do not, such as operation of UWB devices inside vehicles; fixed outdoor applications for surveillance; generic material sensing; and location tracking systems. [31] It is also notable that UWB usage in the

[31] These systems are addressed at Section 15.250 of the Commission's rules dealing with wideband devices, but currently there is no tracking possibility in the lower frequency range (3 to 4 GHz).

medical environment is widespread and increasing. ETSI has prepared a Report (ETSI TR 103 313) containing technical points for medical applications that should be reflected in the regulation of Medical Imaging Systems pursuant to an amended Section 15.503(g) of the Rules.[32]

(c) Section 15.509, Technical Requirements for Ground Penetrating Radars and Wall Imaging Systems and Section 15.510, Technical Requirements for Through-wall Imaging Systems.

45. The main problem with Section 15.509 as currently stated[33] is that it artificially limits user groups, rather than relying on technical parameter specification. A corollary of that concern is that there should be a clear link between the technical regulation and the application of the device. Subsection (b) of the current rule limits the users of GPRs and wall imaging system users to law enforcement, firefighting, emergency rescue, scientific research, commercial mining, or construction purposes. While the term "construction" is capable of a reasonably broad interpretation, a large user group are various professionals, such as land surveyors, construction workers, handymen and plumbers. It is understood that the Commission has in the past wanted to exclude UWB consumer products, but there are those who have reasonable individual, professional applications for such devices and the continuation of the total ban on consumer product UWB devices should be re-evaluated due to the exceptionally low interference potential.

46. The same concerns exist with respect to Section 15.510. Part of the eligibility problems set forth in Section 15.510(b) result from the definition in Section 15.503(h) discussed above. Although a wall imaging system is a field disturbance sensor that is specifically

[32] That rule currently defines a medical imaging system as a field disturbance sensor that is designed to detect the location or movement of objects within the body of a person or animal.

[33] Another issue with this rule section is the requirement of a manual switch for a GPR device that is designed to be operated while being hand held and a wall imaging system. The rule calls for a manually operated switch that causes the transmitter to cease operation within 10 seconds of being released by the operator. This requirement is overly specific. On/off switching can be based on ground and wall contact which can be governed by "movement sensors." GPR devices very often have wheels providing information for signal processing. Others use other types of wall detection sensors, such as inductive sensors, light sensors, or other RF-emissions. More flexibility is called for.

"designed to detect the location of objects contained in a wall or other structure," it is not necessarily the case that every wall or other structure being scanned by the device will in all cases be dense enough and thick enough to absorb all of the signal transmitted by such an imaging system. This absolute requirement is highly exclusionary, if strictly interpreted.[34] Furthermore, that rule section specifically *excludes* devices such as "stud finders" which are designed to locate objects behind gypsum, plaster or similar walls that are not necessarily capable of absorbing the entire transmitted UWB signal. Because of this, the regulations applicable to "wall imaging systems" do not apply to most such devices including all stud finders, though its intended application may be quite clearly consistent with and in fact identical to FCC-defined "wall imaging systems."[35]

47. Instead, most wall scanning devices are properly defined for United States regulatory purposes as "through-wall imaging systems" as per Section 15.503(i), even though that category of devices was apparently intended to apply largely to a very different type of product. The devices intended to be included in this definition are field disturbance sensors intended to detect the movement of persons or objects located on the other side of an opaque structure such as a wall or ceiling. However, anomalously, the Commission's UWB rules specifically include in the definition of *through-wall devices* (apparently out of an abundance of caution to insure conservatively that there would not be interference to licensed radio services occupying the same spectrum as the device) "stud finder" type devices which are "designed to locate objects behind gypsum, plaster or similar walls that are not thick enough or dense enough to absorb the

[34] Bosch would suggest that a more flexible method of distinguishing between wall imaging systems and through-wall imaging systems may be found in the ECC's method of regulating devices capable of "building material analysis." See, ETSI EN 30 065-4, and also ECC Decision (07)01.

[35] This is an anomaly, because the definition in the rules specifically is intended in general to *include* devices. The rules applicable to UWB wall imaging systems include among authorized users those associated with law enforcement, firefighting, emergency rescue, scientific research, commercial mining, *or construction*. See, Section 15.509(b) and the discussion *supra*.

transmitted signal." While what the Commission refers to as "stud finder" type devices are most likely to be utilized by professionals in the construction trade, the rule governing UWB "through-wall imaging systems," Section 15.510(b), restricts users of through-wall scanning devices to "law enforcement, emergency rescue or firefighting organizations that are under the authority of a local or state government." While these first responders most certainly have uses for UWB through-wall imaging systems, the definition seems to include devices specifically intended for professionals in the construction trade. These devices have a great deal of utility in such a capacity, and a reevaluation of permitting them by rule is timely and sensible. Otherwise, the marketing and use of UWB construction equipment is prohibited in the United States regardless of the definitional status of the device. Additionally, the rule perpetuates the process of regulation by waiver employed during the past sixteen years.

48. Because the purpose of Section 15.510(b) (i.e. to prevent interference from UWB devices *ex ante* to licensed terrestrial RF users by limiting deployment of through-wall devices to those having a need for an imaging system to penetrate walls to search for objects) was not intended to proscribe devices that function as wall imaging devices which are needed by small businesses to substantially enhance, expedite and improve construction of buildings in the United States, it is hoped that Commission will revise and either reclassify or combine these rules to accommodate them for the first time, in the proceeding requested herein.

(d) Section 15.511, Technical Requirements for Surveillance Systems.

49. In this case as well, eligibility limitations are overly conservative. Subsection (b) of this rule section limits the use of fixed surveillance systems to those operated by law enforcement, fire or emergency rescue organizations or by manufacturers licensees, petroleum licensees or power licensees as defined in §90.7 of the Commission's Rules. But there is a strong

demand within the "security" industry to use UWB for intrusion alarm systems. The Commission's eligibility limitations preclude any deployment by other than public safety or critical infrastructure entities. Another important industrial application of this technology not now permitted is for air gap monitoring of wireless power transmission of electrical vehicles. The eligibility limitations should either be removed or limited to prohibitions on consumer products, so as to permit consumer surveillance and security systems and industrial applications.

(e) Section 15.517, Technical Requirements for Indoor UWB Systems.

50. Subsection (a) of this section limits operation to UWB transmitters employed solely for indoor operation. For some tracking systems and surveillance applications, outdoor operation should be allowed as well. As discussed above, some interference mitigation requirements would reduce the probability of interference to other radio users, such as duty cycle limitations, antenna pattern limits, and possible limitations in the frequency range deployed for outdoor uses.

(f) Section 15.519, Technical Requirements for Hand Held UWB Systems.

51. Subsection (a) of this Section requires that UWB devices operating under the provisions of this section must be hand held and not employ a fixed infrastructure. The prohibition of communication with a fixed infrastructure precludes the use of UWB for tracking systems. UWB tracking tags require battery operation. Therefore, the transmissions are very time limited (i.e. they utilize low duty cycles and/or low activity factors). It is appropriate to review such usage with an eye toward allowing such systems where the interference potential is shown to be negligible. In one configuration for example, the fixed system could be UWB passive, or the fixed outdoor UWB operation is limited by specific requirements.[36]

(g) 15.521 Technical requirements applicable to all UWB devices.

[36] See, specifically, ETSI EN 302 065-2: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 2: Requirements for UWB location tracking".

52. Currently, per subsection (a) of this Section, UWB devices may not be employed for the operation of toys. Furthermore, operation onboard an aircraft, a ship or a satellite is prohibited. Bosch urges the Commission to reevaluate the applications of UWB technology, including those for ground-based [37] vehicles within or aboard trains, ships, and construction vehicles. For terrestrial vehicular use, the technical rules should take into account the shielding effect of the vehicle, the movement of the vehicle, and other normal mitigation methods such as limited duty cycles, listen-before-transmit and other normal methods. Such outdoor applications could be regulated similarly to indoor applications and interference potential could be limited by means of external field strength limits or other mitigation measures.[38]

53. Subsection (c) of Section 15.221 states as follows:

> (c) Emissions from digital circuitry used to enable the operation of the UWB transmitter shall comply with the limits in §15.209, rather than the limits specified in this subpart, provided it can be clearly demonstrated that those emissions from the UWB device are due solely to emissions from digital circuitry contained within the transmitter and that the emissions are not intended to be radiated from the transmitter's antenna. Emissions from associated digital devices, as defined in §15.3(k), e.g., emissions from digital circuitry used to control additional functions or capabilities other than the UWB transmission, are subject to the limits contained in Subpart B of this part.

This requirement is a major problem for UWB devices and the harmonization process worldwide. UWB limits are below the EMC limit (10dB). This rule subsection precludes use of UWB transmit or receive devices being embedded into another device. If the combined device is regulated by some other transmit or receive requirements, or uses a display or contains other digital circuits, the emissions from these components could be higher than the UWB emissions

[37] While Bosch makes no suggestion with respect to the use of UWB aboard drones or other aeronautical mobile devices, there is in the ECC/EC a specific regulation in place addressing the use of UWB aboard aircraft that could serve as a model for UWB regulation in the United States. See, ETSI EN 302 065-5: " Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU; Part 5: Devices using UWB technology onboard aircraft".

[38] See, ETSI EN 302 065-3: "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 3: Requirements for UWB devices for ground based vehicular applications".

and for compliance testing it is not possible to differentiate between or to separate the emissions. To address this, ETSI developed a test procedure to permit a means to differentiate between the emissions. See, EN 303 883. It would be helpful if the Commission were to address this problem in the revision of the Subpart F rules.

54. The latter portion of Subsection (d) of this rule Section requires "… a resolution bandwidth of 1 MHz, an RMS detector, and a 1 millisecond or less averaging time. Unless otherwise stated, 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. Alternative measurement procedures may be considered by the Commission." In general, this requirement is not problematic, but Bosch would note that many UWB signals are no longer pulsed based and therefore the differences in the emission types and signal characteristics should be reflected in the tests. The same problem exists in Subsection (g) addressing peak measurement resolution bandwidth. ETSI EN 303 883 proposes a signal dependent solution to avoid errors in evaluating the peak power level. The calculation called for by Subsection (g) is correct for pulsed based systems but it could lead to problems for other kinds of UWB signals.

IV. Conclusions.

55. This petition seeks to adopt more flexible UWB rules. The current rules were all adopted in the 2002 *First Report and Order* in an admittedly contentious docket proceeding. It is timely that the Commission revise these conservative, sixteen-year-old rules governing ultra-wideband operation impose substantial limitations on manufacturers and user groups. The current process of regulation of UWB by waiver is costly, slow and precludes innovation. Valuable products that would otherwise benefit numerous industries in the United States are

released to the public late, or precluded entirely due to the difficulties of the process. The Commission should revisit and modify the rules as per the discussion hereinabove and as proposed in the attached Appendix; most especially the definitional requirement for minimum bandwidth determination and testing to demonstrate compliance with minimum bandwidth requirements, in order to promote harmonized UWB rules worldwide.

Therefore, the foregoing considered, Robert Bosch LLC respectfully requests that the Commission review and modify the UWB rules under Part 15, Subpart F as set forth herein and in the attached Appendix, by means of a Notice of Proposed Rule Making issued at an early date.

Respectfully submitted,

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APPENDIX

The following rule sections are amended to read as follows:

1. Section 15.31 Measurement standards.

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(c) Except as otherwise indicated in § 15.256, and except for devices regulated by Subpart F of this Part, for swept frequency equipment, measurements shall be made with the frequency sweep stopped at those frequencies chosen for the measurements to be reported.

2. Section 15.503 Definitions.

(a) UWB bandwidth. For the purpose of this subpart, the UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna. The upper boundary is designated fH and the lower boundary is designated fL. The frequency at which the highest radiated emission occurs is designated fM.

(b) Center frequency. The center frequency, fC, equals (fH + fL)/2.

(c) Fractional bandwidth. The fractional bandwidth equals 2(fH−fL)/ (fH + fL).

(d) Ultra-wideband (UWB) transmitter. An intentional radiator that, during normal operation and in all operating modes of the device, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth. UWB bandwidth is to be determined for non-impulse UWB transmitters by permitting measurements to be made with any hopped, stepped or gating functions active.

(e) Material Sensing Devices. A general category consisting of ground penetrating radar systems, medical imaging systems, wall and through-wall imaging systems, surveillance systems, industrial monitoring systems and radiodetermination systems for the purpose of detection of objects in free space or within or beyond obstacles; or for the determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these parameters. As used in this subpart, Material Sensing Devices do not include systems designed to detect the location of tags, or systems used to transfer voice or data information.

(f) Ground penetrating radar (GPR) system. A field disturbance sensor that is designed to operate only when in contact with, or within one meter of, the ground for the purpose of detecting or obtaining the images of buried objects or determining the physical properties within the ground. The energy from the GPR is intentionally directed down into the ground for this purpose.

(g) Medical imaging system. A field disturbance sensor that is designed to detect the location or movement of objects within the body of a person or animal.

(h) Wall imaging system. A field disturbance sensor that is designed to detect the location of objects contained within a wall or within fixed infrastructure; to determine the physical properties within the wall or within the fixed infrastructure; or to evaluate the integrity of or otherwise evaluate or analyze building materials. Industrial or commercial applications of wall imaging systems do not include detection, location or movement of persons located beyond the materials being evaluated.

(i) Through-wall imaging system. A field disturbance sensor that is designed to detect the location or movement of persons or objects that are located in areas on the other side of an opaque structure such as a wall or a ceiling.

(j) Surveillance system. A field disturbance sensor used to establish a stationary RF perimeter field that is used for security purposes to detect the intrusion of persons or objects, or for the determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these parameters. Location and tracking systems are included, as are material sensing devices.

(k) EIRP. Equivalent isotropically radiated power, i.e., the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna. The EIRP, in terms of dBm, can be converted to a field strength, in dBuV/m at 3 meters, by adding 95.2. As used in this subpart, EIRP refers to the highest signal strength measured in any direction and at any frequency from the UWB device, as tested in accordance with the procedures specified in § 15.31(a) and 15.523 of this chapter.

(l) Law enforcement, fire and emergency rescue organizations. As used in this subpart, this refers to those parties eligible to obtain a license from the FCC under the eligibility requirements specified in § 90.20(a)(1) of this chapter.

(m) Hand held. As used in this subpart, a hand held device is a portable device, such as a lap top computer or a PDA, that is primarily hand held while being operated.

3. Section 15.507 Marketing of UWB equipment.

In some cases, the operation of UWB devices is limited to specific parties, e.g., law enforcement, fire and rescue organizations operating under the auspices of a state or local government, or construction, security or industrial professionals. The marketing of UWB devices must be directed solely to parties eligible to operate the equipment. The responsible party, as defined in § 2.909 of this chapter, is responsible for ensuring that the equipment is marketed only to eligible parties. Marketing of the equipment in any other manner may be considered grounds for revocation of the grant of certification issued for the equipment.

4. Section 15.509 Technical requirements for ground penetrating radars and material sensing systems.

(a) The UWB bandwidth of a material sensing system operating under the provisions of this section must be below 10.6 GHz.

(b) Operation under the provisions of this section is limited to GPRs and imaging systems operated for purposes associated with law enforcement, firefighting, emergency rescue, scientific research, commercial mining, security, industrial or construction applications, land surveying, plumbing and other commercial and professional endeavors. Parties operating this equipment must be eligible for licensing under the provisions of part 90 of this chapter.

(c) A GPR that is designed to be operated while being hand held, and a material sensing system shall contain a manually operated switch that causes the transmitter to cease operation within 10 seconds of being released by the operator. In lieu of a switch located on the imaging system, it is permissible to operate material sensing system by remote control provided the material sensing system ceases transmission within 10 seconds of the remote switch being released by the operator.

(d) The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in § 15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	-65.3
1610-1990	-53.3
1990-3100	-51.3
3100-10600	-41.3
Above 10600	-51.3

(e) In addition to the radiated emission limits specified in the table in paragraph (d) of this section, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	-75.3
1559-1610	-75.3

(f) For UWB devices where the frequency at which the highest radiated emission occurs, fM, is above 960 MHz, there is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on fM. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in § 15.521.

5. Section 15.510 Technical requirements for Material Sensing Systems operated by Law Enforcement, Fire and Emergency Rescue Organizations or by Construction or Industrial Professionals.

(a) The UWB bandwidth of a material sensing system operating under the provisions of this section must be below 960 MHz or the center frequency, fC, and the frequency at which the highest radiated emission occurs, fM, must be contained between 1990 MHz and 10600 MHz.

(b) Operation under the provisions of this section is limited to material sensing systems operated by law enforcement, fire and emergency rescue that are under the authority of a local or state government; or by construction or industrial professionals.

(c) For Material Sensing systems operating with the UWB bandwidth below 960 MHz:

(1) Parties operating this equipment must be eligible for licensing under the provisions of part 90 of this chapter.

(2) The operation of these systems requires coordination, as detailed in § 15.525.

(3) The system shall contain a manually operated switch that causes the transmitter to cease operation within 10 seconds of being released by the operator. In lieu of a switch located on the imaging system, it is permissible to operate an imaging system by remote control provided the imaging system ceases transmission within 10 seconds of the remote switch being released by the operator.

(4) The radiated emissions at or below 960 MHz shall not exceed the emission levels in § 15.209. The radiated emissions above 960 MHz shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	−65.3
1610-1990	−53.3
Above 1990	−51.3

(5) In addition to the radiated emission limits specified in the table in paragraph (c)(4) of this section, emissions from these Material Sensing Systems shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	−75.3
1559-1610	−75.3

(d) For equipment operating with fC and fM between 1990 MHz and 10600 MHz:

(1) The radiated emissions at or below 960 MHz shall not exceed the emission levels in § 15.209 of this chapter. The radiated emissions above 960 MHz shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	−46.3
1610-10600	−41.3
Above 10600	−51.3

(4) In addition to the radiated emission limits specified in the paragraph (d)(3) of this section, emissions from these systems shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	−56.3
1559-1610	−56.3

(5) There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, fM. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in § 15.521.

(e) Material Sensing Systems operating under the provisions of this section shall bear the following or similar statement in a conspicuous location on the device: "Operation of this device is restricted to law enforcement, emergency rescue and firefighter personnel, and construction and industrial professionals."

6. Section 15.511 Technical requirements for surveillance, material sensing and industrial monitoring systems.

(a) The UWB bandwidth of an imaging system operating under the provisions of this section must be contained between 1990 MHz and 10,600 MHz. UWB material sensing, surveillance and industrial monitoring systems may be operated outdoors in fixed or mobile configurations for purposes including monitoring of wireless charging systems and location tracking.

(b) UWB Surveillance, material sensing and industrial monitoring systems for outdoor operation must be installed by persons professionally engaged in security or other industries or businesses.

(c) The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in § 15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	−53.3

1610-1990	−51.3
1990-10600	−41.3
Above 10600	−51.3

(d) In addition to the radiated emission limits specified in the table in paragraph (c) of this section, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	−63.3
1559-1610	−63.3

(e) There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, fM. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in § 15.521.

7. Section 15.521 Technical requirements applicable to all UWB devices.

(a) UWB devices may not be employed for the operation of toys. Operation onboard an aircraft, a ship or a satellite is prohibited but operation on or within terrestrial vehicles, including automobiles, is permitted. Fixed, outdoor UWB devices for security or other purposes is permitted, subject to the limitations specified in this subpart.

(b) Manufacturers and users are reminded of the provisions of §§ 15.203 and 15.204.

(c) Emissions from digital circuitry used to enable the operation of the UWB transmitter shall comply with the limits in § 15.209, rather than the limits specified in this subpart, provided it can be clearly demonstrated that those emissions from the UWB device are due solely to emissions from digital circuitry contained within the transmitter and that the emissions are not intended to be radiated from the transmitter's antenna. Emissions from associated digital devices, as defined in § 15.3(k), e.g., emissions from digital circuitry used to control additional functions or capabilities other than the UWB transmission, are subject to the limits contained in Subpart B of this part.

(d) Within the tables in § § 15.509, 15.511, 15.513, 15.515, 15.517, and 15.519, the tighter emission limit applies at the band edges. Radiated emission levels at and below 960 MHz are based on measurements employing a CISPR quasi-peak detector. Radiated emission levels above 960 MHz are based on RMS average measurements over a 1 MHz resolution bandwidth. The RMS average measurement is based on the use of a spectrum analyzer with a resolution bandwidth of 1 MHz, an RMS detector, and a 1 millisecond or less averaging time. Unless otherwise stated, 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. Alternative measurement procedures may be considered by the Commission.

(e) The frequency at which the highest radiated emission occurs, fM, must be contained within the UWB bandwidth.

(f) When a peak measurement is required, it is acceptable to use a resolution bandwidth other than the 50 MHz specified in this subpart. This resolution bandwidth shall not be lower than 1 MHz or greater than 50 MHz, and the measurement shall be centered on the frequency at which the highest radiated emission occurs, fM. If a resolution bandwidth other than 50 MHz is employed, the peak EIRP limit shall be 20 log (RBW/50) dBm where RBW is the resolution bandwidth in megahertz that is employed. This may be converted to a peak field strength level at 3 meters using E(dBuV/m) = P(dBm EIRP) + 95.2. If RBW is greater than 3 MHz, the application for certification filed with the Commission must contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing.

(h) The highest frequency employed in § 15.33 to determine the frequency range over which radiated measurements are made shall be based on the center frequency, fC, unless a higher frequency is generated within the UWB device. For measuring emission levels, the spectrum shall be investigated from the lowest frequency generated in the UWB transmitter, without going below 9 kHz, up to the frequency range shown in § 15.33(a) or up to fC + 3/(pulse width in seconds), whichever is higher. There is no requirement to measure emissions beyond 40 GHz provided fC is less than 10 GHz; beyond 100 GHz if fC is at or above 10 GHz and below 30 GHz; or beyond 200 GHz if fC is at or above 30 GHz.

(i) The prohibition in § 2.201(f) and 15.5(d) of this chapter against Class B (damped wave) emissions does not apply to UWB devices operating under this subpart.

(j) Responsible parties are reminded of the other standards and requirements cross referenced in § 15.505, such as a limit on emissions conducted onto the AC power lines.