FEDERAL COMMUNICATIONS COMMISSION

47 CFR Part 15

[ET Docket No. 21–363; FCC 23–35; FR ID 153948]

FCC Empowers Short-Range Radars in the 60 GHz Band

AGENCY: Federal Communications Commission.

ACTION: Final rule.

SUMMARY: In this document, the Federal Communications Commission (Commission) revises its rules to provide new opportunities for unlicensed field disturbance sensor (FDS) devices (*e.g.,* radars) to operate in the 57–71 GHz band (60 GHz band) while still ensuring coexistence with other unlicensed technologies in the band. The Commission's decision is a significant step in the continuing expansion and evolution of its rules and will supercharge the development and deployment of new and innovative radar operations—including valuable safety applications that detect unattended children in vehicles and which previously could only be permitted through a waiver of the rules.

DATES: Effective August 23, 2023.

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SUPPLEMENTARY INFORMATION: This is a summary of the Commission's *Report and Order,* ET Docket No. 21–264; FCC 23–35, adopted on May 18, 2023 and released on May 19, 2023. The full text of this document is available for public inspection and can be downloaded at: *https://docs.fcc.gov/public/attachments/FCC-23-35A1.pdf.* Alternative formats are available for people with disabilities (Braille, large print, electronic files, audio format) by sending an email to *FCC504@fcc.gov* or calling the Commission's Consumer and Governmental Affairs Bureau at (202) 418–0530 (voice), (202) 418–0432 (TTY).

Procedural Matters

Final Regulatory Flexibility Analyses. The Regulatory Flexibility Act of 1980, as amended (RFA), requires that an agency prepare a regulatory flexibility analysis for notice and comment rulemakings, unless the agency certifies that ''the rule will not, if promulgated, have a significant economic impact on a substantial number of small entities.'' Accordingly, the Commission has prepared a Final Regulatory Flexibility Analysis (FRFA) concerning the possible impact of the rule changes and/or policy contained in the *Report and Order* on small entities. As required by the RFA, an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the Notice of Proposed Rulemaking (*NPRM*) (86 FR 46661, August 19, 2021). The Commission sought written public comment on the proposals in the *NPRM,* including comments on the IRFA. No comments were filed addressing the IRFA. Accordingly, the Commission has prepared a Final Regulatory Flexibility Analysis (FRFA) concerning the possible impact of the rule changes contained in the document on small entities. The present FRFA conforms to the RFA and can be viewed under Appendix C of the *Report and Order.*

Congressional Review Act. The Commission has determined, and the Administrator of the Office of Information and Regulatory Affairs, Office of Management and Budget, concurs, that this rule is non-major under the Congressional Review Act, 5 U.S.C. 804(2). The Commission will send a copy of this *Report & Order* to Congress and the Government Accountability Office pursuant to 5 U.S.C. 801(a)(1)(A).

Paperwork Reduction Act Analysis. This *Report and Order* does not contain new or modified information collections subject to the Paperwork Reduction Act of 1995 (PRA), Public Law 104–13 (44 U.S.C. 3501–3520). In addition, it does not contain any new or modified information collection burden for small business concerns with fewer than 25 employees pursuant to the Small Business Paperwork Relief Act of 2002, Public Law 107–198, *see* 44 U.S.C. 3506(c)(4).

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Synopsis

As discussed in greater detail below, the rules the Commission adopts set forth distinct technical and operational provisions for unlicensed use in different segments of the band. They will permit new fixed and mobile FDS devices to implement pulse or frequency-modulated continuous-wave (FMCW) techniques to facilitate new use cases including installation on low-flying unmanned aircraft. Importantly, novel use cases that support safety, such as vehicle occupant detection, chest movement detection to determine breathing patterns, and eye lid movement detection to determine driver alertness are also expected to see widespread deployment. This approach recognizes evolution in the proceeding as different unlicensed interests provided information on the wide array of potential uses for FDS devices and developed a consensus approach for accommodating these innovative applications. The Commission's decision is especially well suited to stimulate the rapid development of new products and services in such important areas as healthcare monitoring, personal safety, autonomous vehicles, home and industrial automation, and environmental control.

Background

In 2021, the Commission issued a Notice of Proposed Rulemaking (*NPRM*) that proposed to change the rules in § 15.255 to permit FDS devices to operate at higher power limits and provide a more expansive range of applications than the rules currently allow. The proposals, recognizing the burgeoning interest in allowing the use of mobile radars in the band for innovative and life-saving functions, represented the latest evolution in a band in which unlicensed operations have been permitted for more than 20 years. The Commission attributed this newfound interest to the availability of affordable, mass-produced chipsets that are capable of operating in the band, as well as the prospect of marketing and operating these mobile radar devices on a broad international scale. The *NPRM* noted, for example, that interested parties had formed a 60 GHz Coexistence Study Group that was ''looking into ways to accommodate both unlicensed communications device and FDS operations in the band,'' and whose members had ''encouraged [the Commission] to initiate a rulemaking proceeding to review . . . the rules with a goal of putting in place a new framework to promote further innovation in the 60 GHz band by both unlicensed communications and FDS operations.'' It also recognized that the FCC's 2020 Technological Advisory Council (TAC) panel recommended that the Commission initiate a rulemaking proceeding to examine the unlicensed rules governing 60 GHz operations.

Radars operate by transmitting radiofrequency (RF) signals at targets and analyzing the subsequent reflections to determine the targets' speed, range, and direction. Based on the record before us and prevalent technologies, the two common types of radars the Commission anticipates will

operate in the 60 GHz band are FMCW radars and pulse radars. An FMCW radar transmits a continuous sinusoid signal (chirp) whose frequency changes linearly in time to sweep over a defined frequency band. A collection of evenly spaced chirps constitutes an FMCW radar frame. On the other hand, pulse radars typically transmit nanosecond-long pulses in the time domain that instantaneously spread frequencies across a wide bandwidth. As discussed in greater detail below, the rules adopted herein by the Commission are broad enough to account for use of these radar types.

In the 60 GHz band, radars are regulated under § 15.255 of part 15 of the Commission's rules. The part 15 rules permit low-power intentional radiators (popularly known as ''unlicensed devices'') to operate without an individual license where such use is not anticipated to cause harmful interference to authorized users of the radio spectrum. Unlicensed devices in the 60 GHz band generally include indoor/outdoor communication devices such as WiGig, wireless local area networks (WLANs), outdoor fixed point-to-point communication links, and FDS—which includes radar operations. Unlicensed device users protect the operations of authorized Federal and non-Federal users in the band. These users operate under a variety of allocations, including the Mobile, Fixed, Inter-Satellite, Earth-Exploration Satellite Service (EESS), Space Research, Mobile-Satellite, Radiolocation, Radionavigation, and Radionavigation-Satellite services.

When it first adopted § 15.255 in 1995, the Commission stated its intent to develop the 60 GHz band's potential to achieve communications capabilities similar to fiber and coaxial cable; thus, it originally prohibited FDS operation in the band. When it finalized the rules by adopting a spectrum etiquette three years later, it also included a provision that permitted only fixed FDS operation in the band. In 2016, the Commission expanded unlicensed device use in the band to permit limited mobile radar operations and to extend the use of fixed field disturbance sensors to the 64–71 GHz band. Specifically, the Commission's decision permitted the ''narrow application of mobile radars for short-range interactive motion sensing'' (SRIMS) at reduced power levels to ensure that they would successfully co-exist with co-channel communications devices already permitted to operate in the band. While the Commission did not adopt a specific definition for SRIMS, in permitting narrow use of short-range mobile radars it discussed the work of Google LLC (Google) in developing its ''Soli'' sensor technology, which envisioned that smartphones and other personal devices would be able to sense hand gestures when a user is located at a very short distance from the device to perform functions such as controlling web pages or answering phone calls.

Since 2016, the Commission's Office of Engineering and Technology (OET) has granted focused rule waivers to support discrete radar applications, all based on an increased interest in FDS operation in the 60 GHz band. First, in 2018, OET granted Google a waiver of the emission limits to allow Soli radar devices to operate at a higher output power level than what had been authorized in the rulemaking. The waiver permitted Google to deploy its Soli sensor technology at 10 dBm peak transmitter conducted output power, 13 dBm peak EIRP level, and 13 dBm/MHz power spectral density, with a maximum 10% duty cycle in any 33 ms interval. More recently, in 2021, OET granted waivers to several parties to permit vehicle cabin-mounted radars as well as health-care related and other applications in the 57–64 GHz range at the same power levels as those granted to Google in 2018. These narrowly tailored waivers support an especially compelling public interest—using radar technology to monitor for children left in dangerously hot cars, and to trigger alerts that could save lives. In addition, OET granted a waiver to Leica Geosystems AG in July 2020 that allows a limited number of radars to operate in the 60–64 GHz band on specialized unmanned aircraft for the specific purpose of avoiding collisions with structures, supporting wires, or other fixed objects during structure visual inspection operations.

Under the current rules, FDS operations are limited to fixed operation or when used for SRIMS. While FDS devices are limited to a maximum transmitter conducted output power not to exceed −10 dBm and a maximum EIRP level not to exceed 10 dBm, a fixed FDS device with an occupied bandwidth fully contained within the 61.0–61.5 GHz Industrial, Scientific, and Medical Equipment (ISM) band may operate with average output power levels up to 40 dBm and peak output power levels up to 43 dBm. Finally, operations are prohibited on-board aircraft, except on aircraft that are equipped with a high RF attenuation body (*e.g.,* commercial airliners) while forming a ''closed exclusive on-board communication networks within the aircraft.''

At the time the *NPRM* was issued, there was no uniform consensus for how best to accommodate new FDS radar applications in the 60 GHz band while ensuring coexistence with incumbent unlicensed uses. Nevertheless, the Commission found that the extensive analysis associated with the waiver requests, the widespread consumer use of Google's Soli-equipped devices without reported cases of harmful interference, and the ongoing industry interest in promoting coexistence gave it confidence ''that there is now sufficient information for us to build a record to expand unlicensed mobile radar use beyond the toehold the Commission first provided in 2016 and the narrow waivers that have been issued to date.''

As such, the *NPRM* offered a high level proposal that would have provided for all FDS devices, mobile or fixed, to operate in the 57–64 GHz portion of the band at a maximum of 20 dBm average EIRP, 13 dBm/MHz average EIRP power spectral density, and 10 dBm transmitter conducted output power, along with a maximum 10% duty cycle restriction within any 33 ms interval; allowed fixed and mobile FDS devices to operate across the 57–71 GHz band at the existing 10 dBm EIRP and −10 dBm conducted output power limits specified in the rules, without any duty cycle limitations; and asked about other methods to potentially enhance coexistence in the band. The Commission did not propose any rule revisions that would apply to existing unlicensed communication devices such as WiGig, WLAN, or fixed point-to-point wireless links that currently operate in the 57–71 GHz band. The *NPRM* further recognized that operation at higher power than specified in the Commission's existing rules has been allowed in Europe under general rules for short-range devices, and considered how the Commission might be able to harmonize any revisions with applicable European Telecommunications Standards Institute (ETSI) standards to the extent appropriate. Throughout the *NPRM,* the Commission asked questions about its specific proposals, and also specifically ''s[ought] input on the work results of any other coexistence standards activities (international and domestic) and/or cooperative works between communications and FDS study groups that may have taken place, and how such work may inform its proposals to expand unlicensed use of the band.''

In the time since the *NPRM* was released on July 14, 2021, the record has reflected evolving views on how the Commission can accomplish the goals of the rulemaking. The comment cycle initially showed prevalent disagreements between the radar and

communication proponents, with parties from each group opposing different aspects of the proposals. The large number of *ex parte* filings following the close of the comment period reflect how both sides, individually and jointly, have been engaged in ongoing attempts to resolve their differences with various proposals for power levels and duty cycles/radar transmission off-times based on different segmentations of the 57–64 GHz band. Two recent submissions document the fruit of these labors, and are significant milestones in the history of this proceeding: the Industry Consensus Agreement submitted February 27, 2023 that addresses the interests of both FMCW radars and communications devices, and a separate Pulse Radar Joint Agreement submitted November 10, 2022 that describes technical parameters suitable for pulse radar operations.

Discussion

The targeted changes to the part 15 rules the Commission is adopting are optimized to encourage the development of important innovative FDS applications while promoting the growth of equally important innovative immersive communication applications. Taking into account the record as a whole, including the Industry Consensus Agreement and the Pulse Radar Joint Agreement, as well as the filings in response thereto, the Commission finds that these two types of unlicensed technologies (*i.e.,* radar and communications) can successfully co-exist and expand the applications available in the 60 GHz band under the Commission's revised rules.

First, the Commission clarifies the relationship between radars and FDS applications. The Commission also modifies its rules to expand mobile FDS operations within the 60 GHz band, including within the 61.0–61.5 GHz sub band, where higher powered operations are permitted but only for fixed use; with these modifications, the Commission retires the specific provisions that had been established for SRIMS.

Second, for FDS devices that limit their operating frequencies to the 57–64 GHz portion of the 57–71 GHz band, the Commission permits various EIRP levels along with specific duty cycle restrictions related to specific segmentations of the band. The Commission finds that these distinctions, described in greater detail below, offer the best opportunity for new and existing unlicensed devices to successfully co-exist in the 60 GHz band. In conjunction with these rules, the Commission addresses the applicability of additional technologies and technical approaches that were discussed in the *NPRM.*

Third, the Commission permits FDS operation on-board unmanned aircraft (UA) flying at altitudes less than 121.92 meters (400 feet) above ground level, limited to the 60–64 GHz band, at up to 20 dBm peak EIRP subject to a 50% duty cycle, and discusses how the Commission's new rules for FDS devices relate to existing provisions for limited in-cabin aeronautical use. The Commission also addresses matters related to compliance testing and use of equipment that currently operates under waivers of its existing rules.

Definitional Clarification and Mobile Use Expansion

Definition of FDS/Radar. In the *NPRM,* the Commission stated that, although § 15.3(l) of its rules provides a definition for ''field disturbance sensor,'' one must look to the general part 2 rules to find a definition for ''radar.'' It asked whether the rules related to ''field disturbance sensors'' in § 15.255 are sufficiently broad and flexible to accommodate the classes of devices that parties anticipate will be developed to operate in the 57–71 GHz band and whether the definition contained in part 15 of the rules should be modified to provide greater clarity regarding the relationship between FDS and radars.

The Commission clarifies that radars are a sub-category of FDS as defined in both §§ 15.3(l) and 2.1 of its rules. The Commission further finds that the radar definition in § 2.1 of its rules is sufficiently broad when used in conjunction with the FDS definition of § 15.3(l) to accommodate the types of FDS applications envisioned for the 60 GHz band. The Commission agrees with both Texas Instruments (TI) and IEE Sensing that its rules must allow for the detection of static persons or objects and cover all cases of motion/presence detection, regardless of the particular radar topologies employed, and the Commission finds that modifying the definition in § 15.3(l) of the rules to include radars will achieve this objective. The final rules are set forth, *infra.*

Mobile Use of FDS Devices. The Commission's history of expanding unlicensed use of the 60 GHz band has focused on fixed FDS use, with limited and relatively recently adopted provisions for mobile use. In the *NPRM,* the Commission sought comment on how it should interpret ''fixed'' and whether it should incorporate a specific definition for that term into the part 15 rules. The Commission further observed that a review of the 1998 *Report and Order* that first permitted fixed FDS use in the band suggests the Commission was anticipating a narrow set of applications for industrial settings where the equipment would rarely if ever be moved. In the NPRM of this proceeding and with respect to the 61.0–61.5 GHz band in particular, the Commission tentatively concluded that fixed FDS operations should be interpreted as those instances where an FDS device is stationary and is operating at a discrete location for an indefinite—*i.e.,* more than mere transitory—period. It also sought comment on whether there is a bright line rule to differentiate fixed and mobile FDS operations.

Many commenters express support for eliminating the distinction between fixed and mobile FDS use or ask the Commission to take an agnostic use case approach. Among the commenters that suggest specific definitions, Vayyar says the Commission should interpret ''fixed'' in an expansive manner, such as ''remaining at same geographical location while operating,'' allowing moving the sensor within the premises or to other premises (*e.g.,* within an apartment, hospital, ship, etc.). Google suggests keeping the high power allowed in the 61.0–61.5 GHz band and recommends interpreting ''fixed'' FDS operations as those instances where an FDS device is stationary and is operating at a discrete location for an indefinite period, and Bosch suggests distinguishing between fixed and mobile based on whether the device is mounted on a structure (*e.g.,* building, streetlight, or tower) or connected to permanent infrastructure.

The Commission finds that the record illustrates radar use cases that can be ubiquitous and sufficiently fluid in space (such as on a vehicle, or a hospital equipment cart), such that to fully realize the potential benefits of the band, many radar applications will have mobile characteristics even if they are affixed to equipment that can remain stationary in a particular location while the radar is in operation. Thus, the Commission concludes that the best course is to broadly expand mobile use throughout the band so that fixed and mobile distinctions are generally not relevant for operating under the revised rules. For this reason, the Commission is not adding a specific ''fixed'' definition in its rules for unlicensed FDS devices.

For purposes of the 61.0–61.5 GHz ISM band segment, existing § 15.255(c)(2) of the rules permits a fixed FDS device to operate at up to 40

dBm average EIRP and at up to 43 dBm peak EIRP. Under this rule, a fixed FDS device's occupied bandwidth must be fully contained within the 500-megahertz bandwidth of the 61.0–61.5 GHz band; and it must attenuate its signals outside the 61.0–61.5 GHz band, but still within the 57–71 GHz band, to less than 10 dBm average EIRP and 13 dBm peak EIRP. Google has observed that the high power allowed in this 500-megahertz band would be useful to FDS using narrow bandwidth applications, and the Industry Consensus Agreement recommends retaining the existing power levels permitted in the 61.0–61.5 GHz band while opening the band to mobile applications. Applying the Commission's decision to this band, it removes the ''fixed'' restriction applicable to FDS operation in § 15.255(c)(2). This is consistent with the Commission's intentions to permit both fixed and mobile applications to be deployed within the entirety of the 60 GHz band.

Removal of the SRIMS Designation. Consistent with the Commission's decision to permit fixed and mobile radars to operate throughout the 60 GHz band, the Commission adopts the proposal to remove the term ''short-range interactive motion sensing'' (SRIMS) from the rules. The Commission acknowledges that there has been much confusion on which 60 GHz mobile and fixed radar applications qualify under the SRIMS designation, and notes that commenters unanimously supported the removal of the SRIMS terminology from the rules. Because the FDS rules the Commission is adopting herein will apply to all manners of fixed and mobile technologies operating under § 15.255, and because the SRIMS designation was crafted for a limited type of mobile radar (*i.e.,* short-range motion sensing radar), it is no longer necessary. Accordingly, the Commission removes this designation and associated relevant requirements from the rules.

Expanded Use of FDS Devices Operating in the 57–64 GHz Band

In response to notice that the Commission was considering rules that would promote co-existence between communication devices—especially new immersive technologies—and FDS/radars in the 60 GHz spectrum, the record reflects the disagreements, debates, and ultimate consensus opinions that arose between communications and radar proponents. The rules the Commission is adopting balance the abilities of radar and communication devices to access the same spectrum. The Commission adopts a band plan and associated technical rules that arise from the Commission's original proposals and accounts for the results of a multi-month negotiated agreement between major parties within both the communications and the radar industries, and that no party has opposed.

Under the Commission's revised § 15.255 rules, which are set forth below, the Commission permits the following for FDS devices: (1) up to 20 dBm peak EIRP for indoor operation, and up to 30 dBm peak EIRP for outdoor operation, including all vehicular applications, within the 57.0–59.4 GHz band; (2) up to 3 dBm peak EIRP for all operations within the 57.0–61.56 GHz band; (3) up to 20 dBm peak EIRP for all operations within the 57.0–61.56 GHz band subject to a 50% duty cycle; (4) up to 14 dBm peak EIRP for all operations within the 57–64 GHz band subject to a 22.7% duty cycle; and (5) up to 20 dBm peak EIRP for fixed outdoor operations or vehicular applications (except in-cabin vehicular use cases) within the 57–64 GHz band subject to a 50% duty cycle. In addition, for FDS devices that have a maximum pulse duration of 6 ns, the Commission permits the following: (a) the average EIRP shall not exceed 13 dBm and the transmit duty cycle shall not exceed 10% during any 0.3 μs time window; (b) the average integrated EIRP within the frequency band 61.5–64.0 GHz shall not exceed 5 dBm in any 0.3 μs time window; and (c) peak emissions shall not exceed 20 dB above the maximum permitted average emission limit applicable to the equipment under test. The Commission addresses unlicensed device use while airborne in the portion of this summary titled ''Operation On-board Aircraft,'' *infra.* The adoption of the above technical rules is supported by two industry joint agreements, the Industry Consensus Agreement and the Pulse Radar Joint Agreement which are discussed in greater detail, below. The Commission finds that these different EIRP limits and the respective associated band segmentations along with the different duty cycle limits would provide expanded opportunities for various use cases based on radars' bandwidth usage while ensuring successful co-existence with other users of the band. This approach, proposed by the industry agreements, effectively improves on the Commission's simpler approach of having a single EIRP limit across the entire band as proposed in the *NPRM.* The Commission notes that these EIRP limits are lower than the limits permitted to general communication devices in the band.

Consensus Agreements

Industry Consensus Agreement. The February 27, 2023 Industry Consensus Agreement represents a significant breakthrough, as it resolves longstanding disagreements among various industry segments regarding equitable spectrum access. The Industry Consensus Agreement represented by radar proponents (Amazon.com Services LLC, Continental Corporation, Garmin International, Inc., Google LLC, IEE Sensing Inc., Infineon Technologies Americas Corp., Texas Instruments Incorporated and Vayyar Imaging Ltd.) and unlicensed communications proponents (Intel Corporation, Meta Platforms Inc. and Qualcomm Incorporated), all of whom have been active participants throughout the course of the rulemaking proceeding, represents a viable compromise that has support from both interest groups.

The Industry Consensus Agreement proposes ''soft segmentations'' of the 57–64 GHz band that follows the WiGig channelization scheme to promote communications devices' access to an alternative channel if a radar device is transmitting on the remaining channel(s). The Industry Consensus Agreement also proposes long periods of radar transmission off-times (at least 2 ms in duration) under certain parameters to permit communications devices' necessary access to the same spectrum, thus resolving one of the more highly contested issues within the proceeding—whether and for how long the rules should require FDS devices to adhere to specific time periods of non-transmission. Finally, the Industry Consensus Agreement proposes different EIRP limits in different sub-bands to further ensure successful co-existence between FDS and communications devices while allowing varying EIRP levels necessary to successfully provide different radar applications in each sub-band.

The Industry Consensus Agreement responds to the *NPRM* by proposing more expansive radar operations in portions of the 57–64 GHz band than the Commission proposed, while explaining how the Commission can still meet its goal of ensuring fair sharing with communications operations. For example, the proposal allows radars with 2-gigahertz bandwidth (operating in the 57.0–59.4 GHz band) to transmit at 20 dBm peak EIRP without any transmitter off-time limitations. In place of the prior 2 ms minimum radar transmitter off-time requirement imposed in multiple waivers approved in July 2021, the Industry Consensus Agreement allows FDS/radar devices

with 4.5-gigahertz bandwidth (operating in the band 57.0–61.56 GHz) and 7-gigahertz bandwidth (operating across the entire 57–64 GHz band) to operate with transmission bursts that occupy 50% and 22.7% of the airtime, respectively, but requires the FDS devices to implement continuous silent intervals to prevent non-stop radar transmissions bursts that could severely impact communications devices' latency, as described in the record of the proceeding, *supra.*

Pulse Radar Joint Agreement. Acconeer, the primary proponent for 60 GHz pulse radar technologies in the Commission's record, engaged in lengthy discussions with major communications device proponents represented by Intel, Meta Platforms and Qualcomm to develop technical parameters particular to pulse radars to enable successful co-existence in the 57–64 GHz band. On November 10, 2022, these parties responded to the Commission's *NPRM* by submitting the Pulse Radar Joint Agreement that sets forth specific technical parameters applicable to pulse-style radars that are distinct from those submitted by the Industry Consensus Agreement, and requests that the Commission adopts these parameters into the rules.

As described *supra,* pulse radars typically transmit nanosecond-long pulses that instantaneously spread across the wide intended band. Pulses are emitted in sweeps and multiple sweeps constitute a frame. Acconeer describes that its ''pulse radar transmits in short nanosecond-long pulses that can co-exist with [IEEE] 802.11ad/ay [compliant devices] with low impact on throughput, as the error correction coding of the communication systems are able to cope with the pulse radar in the channel, even under extreme signal-to-interference ratio (SIR)'' conditions unlike other types of radar devices using different coding schemes, such as FMCW radars, ''which perform sweeps continuously during tens of microseconds to tens of milliseconds, making it difficult for [IEEE] 802.11ad/ay [compliant] systems to rely on error correction coding to maintain a high data rate during the slot occupied by the FMCW radar.'' Acconeer further explains that the peak power spectral density for its pulse radar, as measured over an IEEE 802.11ad/ay device's communication channel, is significantly lower than FMCW radars, which decreases potential harmful interference decreasing the likelihood that the listen-before-talk (LBT) mechanism of the IEEE 802.11ad/ay compliant system less will be triggered. Acconeer thus believes that its pulse radar technology, which uses spread spectrum techniques over a wide bandwidth, necessitates different provisions from what may be appropriate for other types of radar technologies.

Discussion. The Commission finds that the technical proposals included in the Industry Consensus Agreement in response to those on which the Commission sought comment provides a reasonable compromise that is well suited to foster its fundamental goal of opening the 60 GHz spectrum to innovative applications while promoting successful sharing between communications and FDS technologies. The Industry Consensus Agreement offers a path for realizing the band's potential to host a wider range of unlicensed users without increasing the risk for harmful interference to authorized users of the band. The Commission notes that parties outside of the signatories to the Agreement, including the Auto Innovators and Robert Bosch LLC have expressed support for the Industry Consensus Agreement. Moreover, because the Industry Consensus Agreement was the product of negotiations between leading stakeholders with interests in both radar and unlicensed communications devices, on balance, the economic benefits experienced by band users will outweigh economic costs. Accordingly, the Commission's final rules draw favorably from this filing.

While the *NPRM* made a specific proposal for expanding the use of the band for FDS use, it also sought comment more broadly on rules that would enable the successful sharing between FDS and communications uses. For example, the *NPRM* proposed to expand FDS operations in the 57–64 GHz band, but alternatively sought comment on allowing the FDS operations across the entire band or some other segment. The *NPRM* proposed that FDS devices be limited to 20 dBm average EIRP while also seeking comment on permitting up to an average power of 40 dBm EIRP and on specifying a peak power rather than an average power. The *NPRM* proposed FDS devices be limited to a duty cycle of 10% based on a maximum 3.3 ms transmission time in every 33 ms interval but also discussed the concerns parties have expressed with the proposed duty cycle and timeframe. The *NPRM* also sought comment on frameworks suggested by the 60 GHz Coexistence Study Group which included taking a channelization approach to radars in the 60 GHz band and having different operating parameters for radars when they are operating in a vehicle, indoors, or outdoors, or between implementations that are fixed, mobile, or portable.

To facilitate use by all technologies, the Commission agrees with Acconeer that because pulse radars necessitate wide bandwidths to accommodate their spread spectrum technique, the Commission must also consider rules that are not solely predicated on using the small partitioned bands outlined in the Industry Consensus Agreement. Although Acconeer appears to be the only pulse radar provider that participated in the proceeding, many commercial parties plan to incorporate the Acconeer pulse radar chip into their finished products and other manufacturers may have plans for similar systems, thus making it likely that pulse FDS devices will see widespread use in the 57–64 GHz band. By adopting technical parameters that are compatible with the Pulse Radar Joint Agreement, the Commission will further enhance the potential for innovative product deployments in the 60 GHz spectrum without increasing the potential for causing harmful interference to authorized users. Because the Pulse Radar Joint Agreement represents the interests of proponents of pulse radar and leading communications device stakeholders, on balance, the economic benefits experienced by band users will outweigh economic costs. Accordingly, the rules the Commission is adopting also recognize the approach set forth in the Pulse Radar Joint Agreement.

Technical Considerations

Frequency range. In the *NPRM,* based on the parameters in the multiple waiver grants that pertain to FDS use of the 60 GHz band, the Commission proposed to limit operation of FDS devices operating under the proposed rules to the 57–64 GHz band to be consistent with the European ETSI Harmonized Standard EN 305 550 that restricts short-range devices, *e.g.,* radars, to the 57–64 GHz band. While the Commission proposed to retain FDS operation in the 64–71 GHz band at the existing low-power limits in the rules, it sought comment on allowing use across the entire 57–71 GHz frequency range at higher power limits in conjunction with a specified duty cycle. In addition, in the *NPRM,* the Commission noted the work of the 60 GHz Co-existence Study Group on developing ''a consensus approach'' to a suitable co-existence framework, with discussions concerning duty cycles; transmission on- and off-times; operating bandwidth and channelization.

Initially, interested parties were unable to achieve consensus on what

frequency range would be most appropriate for expanded FDS use. For instance, Google suggested that limiting operating frequencies for FDS devices to the 57–64 GHz band, consistent with the EN 305 550 standard, would reserve the upper 7 gigahertz of the band for future potential use cases, while both Acconeer and Amazon supported extending the proposed higher power limits to the entire 14-gigahertz spectrum in the 57–71 GHz band to promote more FDS deployment. Other parties addressed potential harmonization benefits in use of the 57–64 GHz band, and suggested that minimizing the level of interference from FDS devices used outdoors in hand-held devices would be useful to facilitate compatibility with future generations of point-to-point radios that are expected to feature the band segment. To protect communications devices' ability to access the spectrum amidst radars' repetitive transmission bursts, a Joint Comment from Intel Corporation, Meta Platforms Inc. and Qualcomm Incorporated proposed that FDS devices limit their operating bandwidth to certain partitions of the 57–64 GHz band if using higher power levels and subject to strict duty cycles. The radar industry initially opposed this approach.

Ultimately, parties representing both FDS and communications interests found common ground in a soft segmentation approach to the 57–64 GHz band. As discussed above, the Industry Consensus Agreement proposes three segments within the 57–64 GHz band, corresponding respectively to WiGig Channel 1 (57.0–59.4 GHz), WiGig Channels 1–2 (57.0–61.56 GHz), and WiGig Channels 1–3 (57–64 GHz). The Pulse Radar Joint Agreement also envisions use of the 57–64 GHz band, but under separate provisions designed to accommodate the technical characteristics of pulse radars. Adopting rules for use of the 57–64 GHz band that account for the existing WiGig channelization plan is preferable to the initial *NPRM* proposal because it provides a level of compatibility among unlicensed device types without imposing uniformly low power levels and band-wide duty cycle limitations that parties indicated would retard continued use and development of the band. Therefore, the Commission is adopting the soft segmentation plan as specified in the Industry Consensus Agreement and the technical parameters for pulse radars as specified in the Pulse Radar Joint Agreement.

EIRP Limits. In the *NPRM,* the Commission proposed allowing FDS devices to operate at no more than 20 dBm average EIRP and asked parties that opposed those limits to propose appropriate parameters. This proposed EIRP limit is higher than the existing limit in the rules which permits fixed FDS devices to operate at no more than 10 dBm peak EIRP and is also higher than the level requested in the multiple waivers that were granted, but is consistent with ETSI EN 305 550. All of the granted waivers permit operation at 13 dBm peak EIRP to provide greater accuracy and finer resolution imaging than the 10 dBm permitted in the rules. The waiver requesters argued that such higher power is necessary to achieve the necessary accuracy needed to detect small-size targets due to poor signal-to-noise ratio conditions. For example, these radars are intended to detect movement or objects in the sub-millimeter range such as the breathing patterns of a child in a car seat, or as in the case of Leica Geosystems AG, thin cables as small as 2.5 mm in diameter.

Radar proponents strongly supported the proposed 20 dBm average EIRP power limit, claiming it is needed to provide the range and sensing detail necessary for many applications, including those that support health and safety. In addition, many of these parties submitted technical studies purporting to demonstrate that radars operating at higher power than currently allowed in the rules would not cause harmful interference to communication devices in the band. On the other hand, Facebook/Intel Corporation/Qualcomm Incorporated (FB *et al.*) argue that radar operations at the proposed 20 dBm EIRP level greatly increase the radar device's zone of interference to communications devices and significantly increases the likelihood that multiple radar devices will interfere with communications devices, and suggested that the Commission adopts a 13 dBm peak EIRP limit, the same as that granted in the waivers. Finally, Blu Wireless opposed the Commission's proposals, arguing that regulatory changes are unnecessary because the native IEEE 802.11ad protocol can be used to perform radar sensing under the existing rules. However, Google disputed that use of this standard and argued that it would produce unsatisfactory outcomes for many of the anticipated new use cases for reasons including performance, complexity and cost.

The Commission finds that the power limits endorsed in the Industry Consensus Agreement, represents the best way forward. Initial comments demonstrated the parties' contention that the Commission's ''one size fits all'' approach would not result in a satisfactory product performance to support anticipated use models. The Commission agrees with the Industry Consensus Agreement that establishing power levels for each band segment of the 57–64 GHz is a better solution for fostering both unlicensed FDS and communications operations in the 60 GHz band while enabling a band sharing approach that can support the capabilities envisioned by the commenters. With respect to the Blu Wireless comments, the Commission notes that operations that were permitted under its existing rules can continue under the revised rules and parties may continue operating under the IEEE 802.11ad protocol if they choose to. However, the Commission finds that there is a strong public benefit in expanding its rules to support the many innovative applications identified by the commenters, and that setting one power limit for all applications is not necessary.

The Commission notes that thorough technical analyses were conducted in 2022 in joint efforts by a Technical Interchange Group (TIG) between the Commission, the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the Department of the Navy, and the National Telecommunications and Information Administration (NTIA). NTIA supports the TIG's consensus conclusion that 60 GHz FDS/radars operating at ground level with the proposed power limits in the *NPRM* would not result in harmful interference to passive EESS sensors in this band because of the high level of atmospheric attenuation that exists between transmitters on the surface of the Earth and the passive sensors in this frequency band. The Commission observes that in the *NPRM,* the Commission proposed a limit of 20 dBm *average* EIRP without any limit on the peak EIRP, but sought comment on whether requiring a peak power limit might be necessary. The technical parameters adopted herein place a limit on the peak EIRP, which is a more stringent requirement that enhances the protection of authorized services and minimizes any potential risk that these operations would cause instantaneous harmful interference. Therefore, the Commission is adopting the EIRP limits provided by Industry in the Industry Consensus Agreement and consistent with the analysis provided by the TIG.

Duty Cycle Limit. One area of particular contention throughout the proceeding has been whether, where, and how to impose a duty cycle limit on FDS operations. There are two components to the duty cycle, the percentage or ratio of the time during

which the transmitter is active versus the time during which there is no transmission and the total period or reference interval during which this ratio is considered. The Commission proposed to require the same 10% duty cycle restriction associated with the multiple waiver grants based on a maximum 3.3 ms total transmission time in every 33 ms interval (which was derived from Google's 2018 final agreement with stakeholders from the WLAN communications industry whose technology operates in the 60 GHz spectrum), and sought comment on whether that or some other duty cycle would be most appropriate.

Radar proponents opposed a duty cycle requirement for FDS operations, stating that it would unnecessarily constrain the radars sensor's capabilities. Parties further claim that limiting transmission time to a maximum of 3.3 ms in every 33 ms interval would be problematic for radars, because isochronous chirp transmission is essential to attain proper measurements. Infineon states that relaxing the 10% duty cycle imposed in the waiver orders would allow the use of more transmit (TX) antennas (generating more virtual antennas) with the same number of chirps for each TX antenna, which in turn would allow higher angular resolution, improving and expanding the radars applications that can be provided in automotive, residential, business, and industrial contexts.

On the other hand, FB *et al.* state that even the 10% duty cycle limit on radar operations by itself does not ensure fair coexistence with communications applications, because radars operate with very short pulses (*i.e.,* radar ''on times'') sent in rapid succession with off times that are at least 90% longer but still unusable by communication systems. These parties argue that communication system transmissions or acknowledgment messages can be either blocked or repeatedly interrupted and corrupted by radars operating with short transmission gaps. The communications proponents advocated for a duty cycle restriction in conjunction with a limit on the duration between radar chirps/pulses (minimum transmitter off-time) to allow for sufficient silent periods during which the spectrum may be accessed—or re-accessed—by communication devices.

In the *NPRM,* the Commission also observed that certain parties had recommended modifying the duty cycle restriction adopted in the waivers to read that ''any radar off-time period between two successive radar pulses that is less than 2 ms shall be considered 'on time' for purposes of computing the duty cycle.'' These parties expressed concern that the duty cycle requirement in the waivers, if expanded to the rules, would not promote coexistence with communications operations, including immersive augmented reality/virtual reality/extended reality (AR/VR/XR) applications, which require very high data throughput and very low latency. In their comments, radar interests claimed that such a rule would impair radar deployment and prevent their ability to meaningfully operate in the band. FB *et al.* offered a contrasting perspective, arguing that communication transmissions or acknowledgment messages would either be blocked or repeatedly interrupted if such a standard is not adopted. They claim that under a 10% duty cycle requirement, radars transmitting short bursts of micro/nano-second durations followed by similarly short silent periods during the entire total 33 ms interval would result in too short of a quiet interval for 60 GHz immersive virtual reality communication devices to effectively access the spectrum—even though such radars would be in technical compliance with the rules. This outcome would be especially harmful for the virtual-reality-enabled headsets and eyewear and other real-time audiovisual applications anticipated for 57–64 GHz band, due to the strict latency they need to operate successfully.

Based on the record, the Commission concludes that a uniform duty cycle requirement as proposed in the *NPRM* will not promote the Commission's interest in expanding the types of unlicensed devices that are able to operate in the 60 GHz band. Both radar and communications interests offer convincing reasons why adopting such a requirement could jeopardize their ability to make productive use of the band. Instead, the Commission notes that the Industry Consensus Agreement provides for frequency band segmentation along with associated EIRP levels and duty cycle/radar transmission off-time solutions that resolves the parties' previous impasse. With respect to pulse radar operations, the duty cycle expressed in the Pulse Radar Joint Agreement provides similar assurances to all parties. Because this duty cycle satisfies the goals the Commission have in the proceeding, the Commission is adopting rules consistent with the provisions of those agreements. Finally, the Commission recognizes that the final rules it is adopting do not follow the duty cycle requirements associated with the ETSI standards.

Transmitter Conducted Output Power Limit. In the *NPRM,* the Commission proposed to allow a maximum (peak) conducted output power for FDS devices, consistent with the waivers the Commission had already granted in the band, but also asked whether a transmitter conducted output limit was necessary for 60 GHz transmitters, including communications and radar devices. The Commission also sought input on whether it should consider adopting an average transmitter conducted output power limit and what impact this would have on the different types of FDS devices (*e.g.,* FMCW, pulse, etc.) envisioned for the band.

The Commission finds that, based on the technical analyses submitted into the record, radars operating in this band typically use a relatively wide antenna beamwidth to detect scattered small objects and fine movements (*e.g.,* chest movements on a patient, hand gestures, obstructive objects, etc.). The Commission agrees with Valeo and Vayyar that modern chip technologies for 60 GHz devices incorporate antenna arrays such that the transmitter output port is difficult to access and thus output power is difficult to directly measure. In such cases, transmitter conducted output power limits are typically calculated for compliance purposes based on the applicant's provided antenna gain information, thereby making such a requirement difficult to enforce. The Commission also observes that the Industry Consensus Agreement suggests completely removing the conducted output power limit from FDS devices operating in specific segments of the 57–64 GHz band. The Commission notes that the rules must address use cases that involve FDS devices that employ wide beamwidth antennas over the entire 57–71 GHz band, in addition to those FDS devices that limit their operation to certain portions of the band. For these reasons, the Commission declines to specify a conducted output power limit in the rules it is adopting for frequency-segmented FDS devices; however, to limit potential harmful interference, the Commission continues to maintain the conducted output power limit for devices that operate over the entire 57–71 GHz band. Similarly, the Commission declines to adopt an antenna gain requirement for FDS devices in lieu of a conducted power limit as such a requirement would result in more complex measurements.

Power Spectral Density Limit. The existing rules do not restrict the power

spectral density for 60 GHz devices. In the *NPRM,* the Commission proposed to require a 13 dBm/MHz EIRP power spectral density on FDS devices, to be consistent with the ETSI limit. This is the same restriction placed on Google and other parties operating FDS devices pursuant to Commission-issued waivers. However, the Commission sought input on the ramifications of not adopting a PSD limit, and instead, relying on the EIRP limits to avoid harmful interference. The Commission notes that a power spectral density limit is not well matched to the nature of radar transmissions—which are in bursts, or chirps. Accordingly, the Commission finds that adopting a power spectral density limit is unnecessary. Commenters have pointed out that while the Commission proposed such a limit with the primary intent to be consistent with ETSI, subsequent changes in the EU regulations have made the Commission's proposal incompatible with that standard. The Commission also agrees with Google that a power spectral density limit may be too restrictive for certain radar use cases with narrow bandwidths. The Commission therefore will not adopt this requirement into the final rules.

Use of Spectrum Sensing Technologies. Although the Commission did not suggest allowing FDS operation at the proposed higher power limits throughout the entire 57–71 GHz band in the *NPRM,* it noted that the Technical Advisory Committee (TAC) suggested the possibility of allowing radars that incorporate a sensing technology such as listen-before-talk (LBT) to operate at the same emission limits as WLAN devices in the band, *i.e.,* 40 dBm EIRP and 27 dBm transmitter conducted output power. Commenters had different reactions to the concept. Acconeer, for example, argued that LBT generally does not provide efficient coexistence among different systems in high millimeter wave frequencies such as the 60 GHz band, where transmissions have high directivity. WISPA further states that LBT would only complicate devices and add latency, driving up equipment costs and forcing a re-design and retrofitting of equipment already deployed in hundreds, if not thousands, of locations. Other parties suggested the Commission could allow FDS devices to operate with power limits as high as those accorded to communication devices (*i.e.,* up to 40 dBm EIRP) if they incorporated spectrum sharing techniques.

Given the Commission's decision to adopt final rules as described above, the Commission sees no need to further pursue the use of spectrum sensing technologies in the 60 GHz band at this time. Nothing in the Commission's decision should be read to preclude standards bodies from developing industry voluntary standards for consideration by the Commission if they determine it is appropriate to do so.

Operation On-Board Aircraft

In the *NPRM,* the Commission stated that it did not anticipate altering the existing restrictions in § 15.255(b) of the rules relating to the use of 60 GHz band unlicensed devices on-board aircraft, but nevertheless sought comment as to whether it should expand the situations where such use is permissible. These restrictions prohibit operation on-board aircraft, except on aircraft that are equipped with a high RF attenuation body (*e.g.,* commercial airliners) while forming ''closed exclusive on-board communication networks within the aircraft,'' such as entertainment systems that deliver movies and music to passengers on-board commercial aircraft. The rule specifically prohibits 60 GHz transmitters from operating on unmanned aircraft, because these types of aircraft do not provide substantial RF shielding. The Commission observed that it has only authorized 60 GHz radars to operate on board aircraft beyond the uses permitted in the rules via waiver in two limited situations in conjunction with specific use cases.

Operation On-Board Unmanned Aircraft (UA)

In its comments, Amazon requests that the final rules allow FDS device use cases on board aircraft in the 60–64 GHz segment of the 60 GHz band for unmanned aircraft. Amazon states that it would like to deploy 60 GHz radar on unmanned aircraft (UA) for obstacle avoidance and situational awareness similar to the use cases the Commission have previously permitted via waiver to Leica Geosystems AG. Amazon states that using 60 GHz radars on drones would enable it and other companies to develop and deploy Near Surround Detection (NSD) systems to enhance the drone's ability to sense and avoid persons and obstacles in and near its ascent and descent path, thereby improving aviation safety as NSD systems provide situational awareness that help prevent collisions. Amazon further claims that authorized drone operations conducted below 121.92 meters (400 feet) above ground level (AGL) in the 60–64 GHz band can coexist with, and will not cause harmful interference to, adjacent Earth-Exploration Satellite Service (EESS) and Radio Astronomy Service (RAS) operations.

Over the course of the rulemaking, the Commission have seen increasing interest in, and support of, Amazon's position. For instance, the General Aviation Manufacturers Association (GAMA) believes that airborne FDS radars operating in the 60 GHz band will not cause harmful interference to other spectrum users, arguing that ''radar devices in this frequency range operate at a relatively low EIRP; the nearest frequency band that is used on aircraft is 24 GHz; and there is existing communications equipment using this same band at the same power where no harmful interference has been observed.'' The Consumer Technology Association, CTIA, Information Technology Industry Council (ITI), NetChoice, TechNet and the U.S. Chamber of Commerce, in a joint comment, assert that allowing the use of this band for low-altitude drone operations would enable systems that sense and avoid obstacles and provide situational awareness to develop; these parties argue that this would help enhance aviation safety and reduce the risk to both people and property on the ground and other airspace users.

The Commission finds that the rules could accommodate 60 GHz FDS operations on UA provided that these operations are limited to the 60–64 GHz sub-band while airborne at low altitudes (less than 121.92 meters (400 feet) above ground level (AGL)) without increasing the potential for interference to authorized services in this band. As the Commission stated in the Leica Waiver Order, limiting operation to the 60–64 GHz frequency band (instead of the entire 57–71 GHz band) avoids the passive EESS band by providing a natural 700-megahertz guard band between the EESS passive service at 57–59.3 GHz and the device's operating band at 60–64 GHz, thus protecting EESS users. The Commission further stated that ''[r]egarding RAS, for which there is no allocation in the 57–71 GHz band, its strict out-of-band limits in the rules already prevent any increase in potential harmful interference caused by the device's operation.'' The Commission also observed that the high oxygen attenuation at frequencies around 60 GHz, added to the fact that the UA is mostly in motion, will serve to mitigate any potential for harmful interference to other users. The Commission further noted that, because fixed outdoor point-to-point 60 GHz transmitters generally use narrow antenna beams, the likelihood that a UA equipped with a 60 GHz radar would be located within the antenna beamwidth of these transmitters is very small,

thereby mitigating any potential increase in harmful interference. The Commission agrees with the logic of these prior assessments, and based on the absence of interference complaints from the Leica deployments since 2020 and support in the record, the Commission finds that 60–64 GHz FDS devices can operate on UA at altitudes less than 121.92 meters (400 feet) above ground level without increasing the potential for harmful interference to authorized services. The Commission also notes that the Federal Aviation Administration (FAA) part 107 rules limit operation of small unmanned aircraft to 121.92 meters (400 feet) AGL. The rules the Commission is adopting herein address the operation of unlicensed FDS devices in the 60 GHz band that may be used on UA and do not alter any obligations under applicable FAA regulations.

Power Levels. With respect to power levels for FDS devices operating on UA, the Commission notes that the Industry Consensus Agreement proposes such operations be limited to 20 dBm peak EIRP with a 50% duty cycle. These EIRP and duty cycle limits are consistent with those permitted in the Leica Waiver Order, and the 60–64 GHz frequency range selected for FDS devices operating on UA avoids the EESS passive band at 57–59.3 GHz with a 700-megahertz guard band, consistent with NTIA's support of the TIG's efforts regarding FDS co-channel use of the EESS band. Accordingly, the Commission is authorizing these parameters for 60–64 GHz FDS operating on-board UA, limited to flying altitudes less than 121.92 meters (400 feet) above ground level. Operations on UA at these power levels will enable more expansive use to deliver new innovative services to the American public without increasing the potential of causing harmful interference to incumbent users.

Operation On-Board Aircraft Other Than UA

As indicated above, § 15.255(b)(2) prohibits operation on aircraft, unless the device is part of ''closed exclusive on-board communication networks within the aircraft.'' However, in 2018, the Commission waived this rule to allow the Google Soli radar incorporated into a smartphone to operate on aircraft without being part of the aircraft's communication network. In the *NPRM,* the Commission noted that compliance options exist for portable electronic devices that may be brought aboard airplanes; these could include, for example, requiring ''airplane mode'' to be activated during flight.

CORF argues that there is no publicly available data on the effect that 60 GHz networking devices on aircraft have on EESS remote sensing in the 57–59.3 GHz band. Therefore, CORF believes it is unreasonable to loosen the standards and allow additional devices such as 60 GHz radars on aircraft. The Frequency Allocation on Remote Sensing (FARS) Committee agrees with CORF's concerns about the accuracy of Google's report on the total reflection of radar signals off of an aircraft window and the absence in Google's report of any discussion regarding the effect of radar signals reflections off of the aircraft wings, and requests that the Commission does not expand airborne use of radars. Conversely, Google states that ''the 2018 Google study did take the effect of radar reflections off of airplane wings into account.'' Google argues that the Soli radar emissions at issue in Google's study are beamed out of the front of the phone; therefore, a user would have to point the phone out of the aircraft window and downward. In such a scenario, ''the user would have difficulty viewing the screen in this configuration, let alone using hand gestures to control any interaction with content on the screen.''

As indicated *supra,* NTIA supports the consensus conclusion of the TIG that the high level of atmospheric attenuation between 60 GHz FDS/radars operating at ground level and the passive EESS sensors operating in the 57.0–59.3 GHz band would not result in any harmful interference to EESS sensors in this band. However, NTIA requests that, if alternate deployment scenarios are considered in the future whereby the atmospheric absorption loss may be different (particularly, aeronautical deployments), further analysis be conducted.

The Commission recognizes and supports the vital interest in protecting the passive EESS services in the 57.0–59.3 GHz band. The Commission also acknowledges that, consistent with NTIA's request, further analysis is being undertaken at this time by the TIG regarding the potential to deploy radars on aircraft in this band. The Commission therefore will only allow FDS/radar operation on aircraft other than UA in the 59.3–71 GHz band at this time, limited to installations within personal portable electronic devices such as smartphones, laptop computers, etc. These radar operations would not need to be part of the on-board communication system within the aircraft.

Implementation Considerations—Compliance Testing

In the *NPRM,* the Commission proposed to exempt FMCW and other similar swept-frequency radars from the § 15.31(c) requirement to stop the frequency sweep when measuring the relevant technical parameters. The Commission explained that stopping the sweep is physically impractical for most of these devices and can result in inaccurate measurements. In addition, the Commission proposed to remove the § 15.255(c)(4) requirement to use an RF detector with a detection bandwidth that encompasses the 57–71 GHz frequency range for performing peak power measurements. The Commission stated that this requirement has been superseded by the more recent inclusion of § 15.255(i), which sets out a flexible approach toward measurement that can be adapted more effectively as device technology and test instrumentation evolve. Finally, the Commission proposed to specify that the provision of § 15.35(c) that requires calculating average field strength over a complete pulse train or 100 ms is not applicable to pulsed or burst radars that operate in the 60 GHz band. The Commission explained that this measurement requirement was originally designed for low frequency pulse-code modulated devices such as garage door openers and would not be appropriate for high frequency radars.

Bosch proposes that instead of measuring transmitter conducted output power, the Commission should consider the equivalent requirement of the total radiated power (TRP), which may be considered and specified as described in ETSI EN 303 883–1 Version 1.2.1 clause 5.6. Bosch argues that this is the only feasible option for measuring the total radiated power of FDS devices. Acconeer argues that using a 20 dB bandwidth to measure wideband pulse systems is challenging, because the low spectral density is usually below the noise flow of the measurement equipment. Additionally, Acconeer proposes that the same method used for evaluating the bandwidth of ultra-wideband (UWB) devices in the 3.1–10.6 GHz band be applied to radar devices in the 60 GHz band. Infineon states that, given that the goal is to establish an average EIRP for purposes of increased compatibility with other 60 GHz Band devices, and different devices may have different cycle periods, a more objective standard that is uniform over all affected radar and FDS devices is appropriate; Infineon proposes that an absolute temporal measure be used, specifically 100 ms. Valeo suggests that

transmission bandwidth should be expressed as a measured occupied bandwidth. If the transmission bandwidth would be specified only by the chirp specification, it could happen that a chirp timing constraint (*e.g.,* maximum chirp slope) may occur. Valeo suggests that the occupied bandwidth be measured, including the overshoots caused by the slew rate of the chirp and the return ramp. Vayyar supports removing the requirement that the sweep is stopped during parts of the compliance testing. The Auto Innovators recommend that compliance measurements should allow evaluation over at least five repetition cycles of the equipment under test (EUT), as it believes this will simplify testing.

The Commission finds that exempting FMCW and other swept-frequency radars from § 15.31(c) is necessary for performing meaningful compliance measurements. In addition, the Commission finds it appropriate to remove § 15.255(c)(4). This rule section was intended to address legacy spectrum analyzers' limited capability for measuring radar waveforms at these frequencies, which is no longer an issue with modern spectrum analyzers. Additionally, the anticipated FMCW and pulsed radar waveforms will likely exceed the 10 MHz video bandwidth specification, resulting in some degree of video averaging. Further, § 15.255(c)(4) specifies that average emission measurements be performed only over a period of active transmission. Retaining such a requirement will prohibit application of a duty cycle correction in determining the average radar transmit power. Finally, the Commission finds that the provision of § 15.35(c) that requires calculating average field strength over a complete pulse train or 100 ms is not applicable to FMCW or to pulsed radar in the 60 GHz band. The Commission disagrees with Bosch's suggestion to consider TRP instead of EIRP. TRP measurements require substantial sampling over the 4π steradian space, thus leading to significant complications in performing compliance measurements. Furthermore, potential interference is essentially driven by the maximum EIRP in the direction of the victim, and due to the highly directional nature of radars, EIRP measurement is correspondingly a more appropriate and efficient compliance measurement. With respect to transmission bandwidth, the Commission agrees with Valeo that the occupied bandwidth be measured as part of the compliance measurements. Doing so will ensure fidelity to the requirements specified in § 2.1049 as required by § 15.201(b). The Commission disagrees with Acconeer's justification for applying the same method used for evaluating the bandwidth of UWB devices to radar bandwidth measurements. UWB devices are held to a very low fundamental power level and thus warrant bandwidth measurement based upon the 10 dB down points to accommodate measurement sensitivity challenges. The higher power limits provided to 60 GHz radar will permit the measurement of occupied bandwidth, even in a radiated measurement, with adequate sensitivity.

Operation of Equipment Subject to Prior Waivers and Transition Provisions

As noted above, a number of parties have been granted waivers of certain provisions of § 15.255 to permit operation of innovative radar devices in the 60 GHz band. In the *NPRM,* the Commission noted that, to the extent that the rules are modified to expand unlicensed FDS device operations in the 60 GHz band, all future 60 GHz FDS operations would be conducted subject to the Commission's modified rules. The Commission proposed to terminate all previously granted 60 GHz FDS waivers and FDS device manufacturers would be expected to conform their operations to its rules as revised.

Most commenters agree that if the adopted 60 GHz technical and operational rules are more stringent than existing FDS waiver conditions, the Commission should grandfather the existing, more flexible waivers for approved radar devices or, at minimum, provide a reasonable transition period for waiver holders to bring their technology into compliance with more rigorous regulatory standards. The Industry Consensus Agreement suggests a six-month transition period applicable only to new certifications under the terms of the waivers. The Pulse Radar Joint Agreement suggested that Acconeer be permitted to continue to market and sell pulse radars under its existing waiver for two years after the effective date of new rules.

The Commission agrees that it is appropriate to afford parties that are operating unlicensed 60 GHz band FDS equipment under waivers a period of time to transition to the new rules and to sell products that they have produced under the terms of their waivers, but the Commission also wants to encourage parties to begin producing equipment that complies with the new rules in a timely manner, notwithstanding whether their existing waivers are more restrictive than the newly adopted rules. The Industry Consensus Agreement shows that manufacturers are comfortable that a relatively short, six-month, period is a realistic and manageable transition time period. The Commission agrees that this is an appropriate timeframe, given that it is important to begin the transition to the new rules as soon as practicable. Accordingly, in these cases where a waiver has previously been granted, the Commission will require that all new FDS/radar devices that are approved by Telecommunication Certification Bodies (TCBs) beginning six months after the effective date of the rules adopted in the proceeding must comply with the new rules. The Commission terminates the 60 GHz band waivers that are currently in effect at the conclusion of this transition period. However, the Commission specifies that so long as a 60 GHz FDS/radar does not cause harmful interference, it can continue to operate until its natural replacement. Any equipment currently operating pursuant to a waiver that is subsequently modified, however, must be brought into compliance with the new rules.

Ordering Clauses

Accordingly, *it is ordered* that, pursuant to the authority contained in sections 4(i), 302, 303(b), (c), (e), (f), (r), and 307 of the Communications Act of 1934, as amended, 47 U.S.C. 154(i), 302a, 303(b), (c), (e), (f), (r), 307, this document *is hereby adopted*.

It is further ordered that part 15 of the Commission's rules *is amended* as specified in below, and such rule amendments *will become effective* 30 days after the date of publication in the **Federal Register**.

It is further ordered that the 60 GHz waivers currently in effect, as granted in DA 18–1308, DA 20–795, DA 21–407, DA 21–811, DA 21–812, DA 21–813, DA 21–814, DA 21–815, and DA 21–816 are *terminated* effective six months after the effective date of the rule amendments adopted herein unless expressly extended by the Chief, Office of Engineering and Technology. However, a device that was certified to be marketed and to operate under waiver on or before six months after the effective date of the rule amendments adopted herein *may continue to be marketed and operate* in accordance with the terms of its certification so long as the device does not cause harmful interference.

It is further ordered that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, *shall send* a copy of the *Report and Order,* including the

Final Regulatory Flexibility Analyses, to the Chief Counsel for Advocacy of the U.S. Small Business Administration.

It is further ordered that the Commission *shall send* a copy of this *Report and Order* in a report to be sent to Congress and the Government Accountability Office pursuant to the Congressional Review Act, *see* 5 U.S.C. 801(a)(1)(A).

List of Subjects in 47 CFR Part 15

Communications equipment, Computer technology, Field Disturbance Sensor, Radar, Radio, and Telephone.

Federal Communications Commission.

Marlene Dortch,

Secretary.

Final Rules

For the reasons discussed in the preamble, the Federal Communications Commission amends 47 CFR part 15 as follows:

PART 15—RADIO FREQUENCY DEVICES

■ 1. The authority citation for part 15 continues to read as follows:

Authority: 47 U.S.C. 154, 302a, 303, 304, 307, 336, 544a, and 549.

■ 2. Amend § 15.3 by revising paragraph (l) to read as follows:

§ 15.3 Definitions.

* * * * *

(l) *Field disturbance sensor.* A device that establishes a radio frequency field in its vicinity and detects changes in that field resulting from the movement of persons or objects within its range. A radar operating pursuant to the definition for radiodetermination station in § 2.1 of this chapter is an example of a field disturbance sensor.

* * * * *

■ 3. Amend § 15.31 by revising paragraph (c) to read as follows:

§ 15.31 Measurement standards.

* * * * *

(c) Except as otherwise indicated in §§ 15.255 and 15.256, for swept frequency equipment, measurements shall be made with the frequency sweep stopped at those frequencies chosen for the measurements to be reported.

* * * * *

■ 4. Amend § 15.35 by revising paragraph (c) to read as follows:

§ 15.35 Measurement detector functions and bandwidths.

* * * * *

(c) Unless otherwise specified, *e.g.,* §§ 15.255 and 15.256(l)(5), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to Supplier's Declaration of Conformity.

■ 5. Amend § 15.37 by adding paragraph (r) to read as follows:

§ 15.37 Transition provisions for compliance with this part.

* * * * *

(r) Field disturbance sensor/radar devices being marketed or operating in the frequency band 57–64 GHz approved by Telecommunication Certification Bodies as being in compliance with previously adopted rules or waivers thereof on or before [six months after the effective date of the rules] may continue to be marketed and operate in accordance with their certifications. All other field disturbance sensor/radar devices shall comply with the requirements in § 15.255.

■ 6. Amend § 15.255 by:
■ a. Removing paragraphs (a)(1) and (2) and revising paragraph (a);
■ b. Adding a subject heading to the introductory text of paragraph (b);
■ c. Revising paragraph (b)(2)(ii);
■ d. Adding paragraphs (b)(2)(iii) and (b)(3);
■ e. Revising the introductory text of paragraphs (c) and (c)(1) and paragraphs (c)(2) through (4);
■ f. Revising paragraph (d) introductory text to be an italicized subject heading;
■ g. Revising paragraph (e) introductory text, (e)(1) and (2), and removing paragraph (e)(3);
■ h. Adding a subject heading to paragraphs (g) and (h); and
■ i. Revising paragraph (i).

The revisions and additions read as follows:

§ 15.255 Operation within the band 57–71 GHz.

(a) *General.* Operation under the provisions of this section is not permitted for equipment used on satellites.

(b) *Operation on aircraft.* * * *

(2) * * *

(ii) Except as permitted in paragraph (b)(3) of this section, equipment shall not be used on aircraft where there is little attenuation of RF signals by the body/fuselage of the aircraft.

(iii) Field disturbance sensor/radar devices may only operate in the frequency band 59.3–71.0 GHz while installed in passengers' personal portable electronic equipment (*e.g.,* smartphones, tablets) and shall comply with paragraph (b)(2)(i) of this section, and relevant requirements of paragraphs (c)(2) through (c)(4) of this section.

(3) Field disturbance sensors/radar devices deployed on unmanned aircraft may operate within the frequency band 60–64 GHz, provided that the transmitter not exceed 20 dBm peak EIRP. The sum of continuous transmitter off-times of at least two milliseconds shall equal at least 16.5 milliseconds within any contiguous interval of 33 milliseconds. Operation shall be limited to a maximum of 121.92 meters (400 feet) above ground level.

(c) *Radiated power limits.* Within the 57–71 GHz band, emission levels shall not exceed the following equivalent isotropically radiated power (EIRP):

(1) Devices other than field disturbance sensors shall comply with one of the following power limits, as measured during the transmit interval:

* * * * *

(2) Field disturbance sensors/radars shall not exceed −10 dBm peak conducted output power and 10 dBm peak EIRP except that field disturbance sensors/radars that limit their operation to all or part of the specified frequency band may operate without being subject to a transmitter conducted output power limit if they operate in compliance with paragraph (b)(3) of this section or with one or more of the provisions below:

(i) *57.0–59.4 GHz:* the peak EIRP level shall not exceed 20 dBm for indoor operation or 30 dBm for outdoor operation;

(ii) *57.0–61.56 GHz:* the peak EIRP shall not exceed 3 dBm except that the peak EIRP shall not exceed 20 dBm if the sum of continuous transmitter off-times of at least two milliseconds equals at least 16.5 milliseconds within any contiguous interval of 33 milliseconds;

(iii) *57.0–64.0 GHz:*

(A) The peak EIRP shall not exceed 14 dBm, and the sum of continuous transmitter off-times of at least two milliseconds shall equal at least 25.5 milliseconds within any contiguous interval of 33 milliseconds, except as specific in paragraph (c)(2)(iii)(B) of this section;

(B) The peak EIRP shall not exceed 20 dBm, and the sum of continuous transmitter off-times of at least two milliseconds shall equal at least 16.5 milliseconds within any contiguous interval of 33 milliseconds when operated outdoors:

(1) As part of a temporary or permanently fixed application; or

(2) When being used in vehicular applications to perform specific tasks of moving something or someone, except for in-cabin applications;

(iv) A field disturbance sensor may operate in any of the modes in the above sub-sections so long as the device operates in only one mode at any time and does so for at least 33 milliseconds before switching to another mode.

(v) *61.0–61.5 GHz:* For field disturbance sensors/radars that occupy 500 MHz bandwidth or less that are contained wholly within the frequency band 61.0–61.5 GHz, the average power of any emission, measured during the transmit interval, shall not exceed 40 dBm, and the peak power of any emission shall not exceed 43 dBm. In addition, the average power of any emission outside of the 61.0–61.5 GHz band, measured during the transmit interval, but still within the 57–71 GHz band, shall not exceed 10 dBm, and the peak power of any emission shall not exceed 13 dBm.

(3) For pulsed field disturbance sensors/radars operating in the 57–64 GHz band that have a maximum pulse duration of 6 ns, the average EIRP shall not exceed 13 dBm and the transmit duty cycle shall not exceed 10% during any 0.3 μs time window. In addition, the average integrated EIRP within the frequency band 61.5–64.0 GHz shall not exceed 5 dBm in any 0.3 μs time window. Peak emissions shall not exceed 20 dB above the maximum permitted average emission limit applicable to the equipment under test. The radar 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.

(4) The provisions in § 15.35(b) and (c) that require emissions to be averaged over a 100 millisecond period and that limits the peak power to 20 dB above the average limit do not apply to devices operating under paragraphs (c)(2) and (3) of this section.

(d) *Limits on spurious emissions.* * * *

(e) *Limits on transmitter conducted output power.*

(1) Except as specified in paragraph (e)(2) of this section, the peak transmitter conducted output power of devices other than field disturbance sensors/radars shall not exceed 500 mW. Depending on the gain of the antenna, it may be necessary to operate the intentional radiator using a lower peak transmitter output power in order to comply with the EIRP limits specified in paragraph (c) of this section.

(2) Devices other than field disturbance sensors/radars with an emission bandwidth of less than 100 megahertz must limit their peak transmitter conducted output power to the product of 500 mW times their emission bandwidth divided by 100 megahertz. For the purposes of this paragraph, emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kilohertz resolution bandwidth spectrum analyzer. The center frequency must be stationary during the measurement interval, even if not stationary during normal operation (*e.g.,* for frequency hopping devices).

* * * * *

(g) *Radio frequency radiation exposure.* * * *

(h) *Group installation.* * * *

(i) *Compliance measurement.* Measurement procedures that have been found to be acceptable to the Commission in accordance with § 2.947 of this chapter may be used to demonstrate compliance.

(1) For purposes of demonstrating compliance with this section, corrections to the transmitter conducted output power may be made due to the antenna and circuit loss.

(2) Compliance measurements of frequency-agile field disturbance sensors/radars shall be performed with any related frequency sweep, step, or hop function activated.

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