

FCC FACT SHEET***Allowing Expanded Flexibility and Opportunities for Unlicensed Operations in the 60 GHz Band**
Report and Order, ET Docket No. 21-264

Background: Building on the Commission’s longstanding history of supporting new and innovative unlicensed operations in the 57-71 GHz band (60 GHz band), this Report and Order would adopt rules to expand opportunities for unlicensed mobile radar operations that can be used to alert drivers to children left in dangerously hot cars, improve mobility and health outcomes by detecting hand gestures and respiratory functions, and assist drones in construction, emergency rescue, and commercial settings. At the same time, the rules will continue to support unlicensed communications applications that are becoming increasingly important for use in virtual reality (VR) headsets and other state-of-the-art devices.

The operational policies and technical parameters for 60 GHz band unlicensed device operation are set forth in Section 15.255 of the our rules. Unlicensed communication devices that operate in the band generally include indoor/outdoor communication devices such as WiGig, wireless local area networking devices, and outdoor fixed point-to-point communication links. Unlicensed radar devices, a type of field disturbance sensor (FDS), are allowed in fixed applications and, when operating on a mobile basis, are permitted but are currently limited to short-range interactive motion sensor applications.

In the Notice of Proposed Rulemaking (NPRM) that initiated this proceeding the Commission noted that recent technological advancements for radar devices are providing new opportunities for unlicensed mobile radar applications, but also recognized that the existing rules contain power and operational limitations that have served to limit what can be realized in the band. Although a series of waivers issued between 2018 and 2021 allowing mobile radar operations at increased power levels and in specific situations served such compelling interests as helping to prevent child deaths, that relief only applied to narrow situations and demonstrated the strong public interest in initiating a rulemaking proceeding.

The draft Report and Order recognizes the work that unlicensed radar and communication user interests have taken over the course of this proceeding to identify a path that expands unlicensed operations while promoting operational compatibility. Two recent submissions are especially significant in this regard: the Industry Consensus Agreement and a separate Pulse Radar Joint Agreement.

What the Report and Order Would Do:

- Adopt the NPRM proposals to permit mobile FDS operations throughout the 60 GHz band and clarify that radars are a type of FDS operations;
- Establish technical rules for devices other than pulse radars (e.g., frequency-modulated continuous-wave radars) that specify different power levels and duty cycle restrictions in specific segments of the band, based on the Industry Consensus Agreement;
- Establish technical rules for devices operating as pulse radars, based on the Pulse Radar Joint Agreement, to account for the different technical considerations that are associated with pulse radar operations;
- Find the provisions for short-range interactive motion sensing are no longer needed due to the increased ability to deploy both fixed and mobile radars in the band;
- Allow unlicensed radars to be operated on board unmanned aircraft (i.e., drones) flying at altitudes less than 400 feet above ground level, limited to the 60-64 GHz band; and
- Address matters related to compliance testing and the use of equipment that currently operates under waivers of the existing rules.

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

In the Matter of)
)
Amendment of Section 15.255 of the) ET Docket No. 21-264
Commission’s Rules)

REPORT AND ORDER*

Adopted: []

Released: []

By the Commission:

I. INTRODUCTION

1. In this Report and Order, we revise our 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. Our decision is a significant step in the continuing expansion and evolution of our 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.

2. Our decision also reflects the work that unlicensed radar and communication user interests have taken over the course of this proceeding to identify a path to promote operational compatibility, as well as the engagement of Federal government entities that are authorized to operate in the band. The contributions and subsequent agreement among these diverse groups gives us confidence that the rules we adopt will successfully expand unlicensed radar use while promoting compatibility with unlicensed communications operations that have long been permitted in the band. We also uphold the fundamental principle that all unlicensed operations in the band—whether operating as communications devices or new radar applications—must not cause harmful interference to licensed and authorized Federal and non-Federal users.

3. As discussed in greater detail below, the rules we adopt set forth distinct technical and operational provisions for 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 aeronautical vehicles. 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

* This document has been circulated for tentative consideration by the Commission at its May 18, 2023 open meeting. The issues referenced in this document and the Commission’s ultimate resolution of those issues remain under consideration and subject to change. This document does not constitute any official action by the Commission. However, the Chairwoman has determined that, in the interest of promoting the public’s ability to understand the nature and scope of issues under consideration, the public interest would be served by making this document publicly available. The FCC’s *ex parte* rules apply and presentations are subject to “permit-but-disclose” *ex parte* rules. *See, e.g.*, 47 CFR §§ 1.1206, 1.1200(a). Participants in this proceeding should familiarize themselves with the Commission’s *ex parte* rules, including the general prohibition on presentations (written and oral) on matters listed on the Sunshine Agenda, which is typically released a week prior to the Commission’s meeting. *See* 47 CFR §§ 1.1200(a), 1.1203.

consensus approach for accommodating these innovative applications. Our 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.

II. BACKGROUND

4. In 2021, the Commission issued a Notice of Proposed Rulemaking (*NPRM*) that proposed to change the rules in section 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.¹ 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.² 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.”³ 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.⁴

5. Radars operate by transmitting radiofrequency (RF) signals at targets and analyzing the subsequent reflections to determine the targets’ speed, range, and direction.⁵ Based on the record before us and prevalent technologies, the two common types of radars that we anticipate 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 we are adopting are broad enough to account for use of these radar types.

6. In the 60 GHz band, radars are regulated under section 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.⁶ Unlicensed devices in the 60 GHz band

¹ *Amendment of Section 15.255 of the Commission’s Rules*, ET Docket 21-264, Notice of Proposed Rulemaking, 36 FCC Rcd 11901 (2021) (*NPRM*).

² *NPRM*, 36 FCC Rcd at 11904, para. 9.

³ *NPRM*, 36 FCC Rcd at 11906, para. 12.

⁴ *NPRM* 36 FCC Rcd at 11906, para. 13.

⁵ See 47 CFR § 2.1(c) (radar is “[a] radiodetermination system based on the comparison of reference signals with radio signals reflected, or retransmitted, from the position to be determined.”); ITU Radio Regulations 1.100-102 (2012).

⁶ The fundamental operating conditions under part 15 are that the operator of a part 15 device has no vested right to continued use of any given frequency, must accept interference that may be caused by the operations of authorized users or other unlicensed devices, and must not cause harmful interference it causes. Should harmful interference occur, the operator is required to immediately correct the interference problem, even if correction of the problem requires ceasing operation of the part 15 equipment causing interference. 47 CFR § 15.5.

generally include indoor/outdoor communication devices such as WiGig,⁷ wireless local area networks (WLANs),⁸ outdoor fixed point-to-point communication links, and FDS—which includes radar operations.⁹ 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.¹⁰

7. When it first adopted Section 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.¹¹ When it finalized the rules by adopting a spectrum etiquette¹² three years later, it also included a provision that permitted only fixed FDS operation in the band.¹³ 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.¹⁴ 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.¹⁵

⁷ WiGig, alternatively known as 60 GHz Wi-Fi, refers to a set of 60 GHz wireless network protocols. It includes the current Institute of Electrical and Electronics Engineers (IEEE) IEEE 802.11ad standard and also the upcoming IEEE 802.11ay standard. The name *WiGig* comes from Wireless Gigabit Alliance, the original association being formed to promote the adoption of IEEE 802.11ad. However, it is now certified by Wi-Fi Alliance. See <https://www.wi-fi.org/discover-wi-fi/wi-fi-certified-wigig>.

⁸ A wireless LAN (WLAN) is a wireless network that links two or more devices using wireless communication to form a local area network (LAN) within a limited area such as a home, school, computer laboratory, campus, or office building. See generally Wi-Fi Alliance, *Wi-Fi Certified WiGig*, <https://www.wi-fi.org/discover-wi-fi/wi-fi-certified-wigig>.

⁹ As discussed *infra*, the Commission has a long history of considering radar devices in Part 15 of the rules as a subset of FDS. See, e.g., 47 CFR §§ 15.503, 15.515. Unless specifically noted, we use the terms "FDS" and "radar" herein interchangeably.

¹⁰ 47 CFR § 2.106. Industrial, scientific and medical (ISM) equipment may also operate in the band at 61.00-61.50 GHz, pursuant to 47 CFR § 18.301.

¹¹ *Amendment of Parts 2, 15 and 97 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications*, ET Docket No. 94-124, First Report and Order and Second Notice of Proposed Rule Making, 11 FCC Rcd 4481, 4488, para. 14 (1995).

¹² A spectrum etiquette is a set of rules to facilitate accessing and sharing of the same spectrum among all authorized users.

¹³ The provisions for fixed FDS operations were part of the spectrum etiquette developed by the Millimeter Wave Communications Working Group (MWCWG) at the behest of the Commission to facilitate coexistence of all 60 GHz devices in the 57-64 GHz band and adopted into the rules in 1998. See *Amendment of Parts 2, 15 and 97 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications*, ET Docket No. 19-124, Third Report and Order, 13 FCC Rcd 15074 (1998).

¹⁴ 31 FCC Rcd at 8133-8134, para. 337 (2016).

¹⁵ *Id.* Google developed the Soli sensor to capture motion in a three-dimensional space using a radar beam, which enables persons to use gestures and motions to control a smartphone's functions or features. See <https://atap.google.com/soli>.

8. 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.¹⁶ 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.¹⁷ 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 2018.¹⁸ 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.¹⁹ 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.²⁰

9. Under the current rules, FDS operations are limited to fixed operation or when used for SRIMS.²¹ 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.²² 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.”²³

¹⁶ *Google LLC Request for Waiver of Section 15.255(c)(3) of the Commission's Rules Applicable to Radars used for Short Range Interactive Motion Sensing in the 57-64 GHz Frequency Band*, DA 18-1308, Order, 33 FCC Rcd 12542 (OET 2018) (*Google Waiver*).

¹⁷ The waiver permitted a 20 dB increase in the conducted power and a 3 dB increase in the EIRP over what the rules currently permit.

¹⁸ *Vayyar Imaging Ltd. Request for Waiver of Section 15.255(c)(3) of the Commission's Rules for Radars used for Interactive Motion Sensing in the frequency band 57-64 GHz*, ET Docket Nos. 20-15, 20-121, 20-263, 20-264, 20-435, and 20-434, Order, DA 21-407 (OET 2021). See also, *Petition of Faurecia Clarion Electronics North America regarding 47 CFR § 15.255*, Order, DA 21-811 (OET Jul. 9, 2021); *Request by Texas Instruments Incorporated for Waiver of 47 CFR § 15.255(c)(3)*, Order, DA 21-812 (OET Jul. 9, 2021); *Request by Amazon.com Services LLC for Waiver of 47 CFR § 15.255(c)(3)*, Order, DA 21-813 (OET Jul. 9, 2021); *Request by Acconeer AB for Waiver of 47 CFR § 15.255(c)(3) rules*, Order, DA 21-814 (OET Jul. 9, 2021); *Request by Vayyar Imaging Ltd. for Waiver of 47 CFR § 15.255 rules*, Order, DA 21-815 (OET Jul. 9, 2021); *Request by Hyundai Mobis Co., Ltd. for Waiver of 47 CFR §§ 15.255(a)(2) & (c)(3)*, Order, DA 21-816 (OET Jul. 9, 2021).

¹⁹ *FCC Permits Hot-Car Sensors to Save Children*, Press Release (April 14, 2021) <https://www.fcc.gov/document/fcc-permits-hot-car-sensors-save-children>.

²⁰ *In the Matter of Leica Geosystems AG Request for Waiver of Section 15.255 of the Commission's Rules Applicable to Radars used on Unmanned Aerial Vehicles in the 60-64 GHz Frequency Band*, ET Docket No. 19-350, DA 20-795, Order, 35 FCC Rcd 7929 (OET 2020) (*Leica Waiver Order*).

²¹ 47 CFR § 15.255(a)(2).

²² 47 CFR § 15.255(c)(2), (c)(3), respectively.

²³ This refers to entertainment systems that deliver movies and music to passengers on-board commercial aircraft. 47 CFR § 15.255(b). The rule, which specifically prohibits operation of 60 GHz transmitters on-board unmanned aircraft (UA) because these types of aircraft do not provide substantial RF shielding, serves to protect EESS passive sensors as well as Radio Astronomy Service (RAS) operations. See *Amendment of Parts 2, 15, and 97 of the Commission's Rules to Permit Use of Frequencies Above 40 GHz for New Radio Applications*, ET Docket No.

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10. 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 threshold the Commission first provided in 2016 and the narrow waivers that have been issued to date."²⁴

11. 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.²⁵ 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.²⁶ 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,²⁷ and considered how we 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 our proposals to expand unlicensed use of the band."²⁸

12. In the time since the *NPRM* was released on July 14, 2021, the record has reflected evolving views on how we 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

94-124, FCC 95-499, First Report and Order and Second Notice of Proposed Rule Making, 11 FCC Rcd 4481, 4496-97, para. 35 (1995).

²⁴ *NPRM*, 36 FCC Rcd at 11909, para. 19.

²⁵ *NPRM*, 36 FCC Rcd at 11901, para. 2.

²⁶ Example of such devices can be found at manufacturers' websites such as <http://www.airlinx.com> and <https://www.ignitenet.com/technology/metroling/>.

²⁷ *NPRM*, 36 FCC Rcd at 11905, para. 10. The European Telecommunications Standards Institute (ETSI) describes short-range devices (SRD) as radio transmitters that offer a low risk of interference with other radio services, usually because their transmitted power, and hence their range, is low. This definition "Short Range Device" can encompass many different types of wireless equipment, including but not limited to door and gate openers, alarms and movement detectors, medical implants and remote control devices. See <https://www.etsi.org/technologies/short-range-devices#:~:text=Standards-,Introduction,hence%20their%20range%2C%20is%20low>. ETSI regulations for SRD operating in the 57-64 GHz band are found in ETSI EN 305 550-1 V1.2.1 (2014-10), Clause 7.2.2, https://www.etsi.org/deliver/etsi_en/305500_305599/30555001/01.02.01_60/en_30555001v010201p.pdf; 47 CFR § 15.255(c)(3). ETSI released an updated draft version of this standard in 2017 which has the same EIRP and PSD limits in the 57-64 GHz band as the 2014 version. See ETSI EN 305 550 V2.1.0 (2017-10), Clauses 4.3.3.3 and 4.3.4.3, https://www.etsi.org/deliver/etsi_en/305500_305599/305550/02.01.00_20/en_305550v020100a.pdf.

²⁸ *NPRM*, 36 FCC Rcd at 11915, para. 33.

cycles/radar transmission off-times based on different segmentations of the 57-64 GHz band.²⁹ 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,³⁰ and a separate Pulse Radar Joint Agreement submitted November 10, 2022 that describes technical parameters suitable for pulse radar operations.³¹

III. DISCUSSION

13. The targeted changes to the Part 15 rules that we are 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, we find 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 our revised rules.

14. First, we clarify the relationship between radars and FDS applications. We also modify our 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, we retire the specific provisions that had been established for SRIMS.

15. Second, for FDS devices that limit their operating frequencies to the 57-64 GHz portion of the 57-71 GHz band, we permit various EIRP levels along with specific duty cycle³² restrictions related to specific segmentations of the band. We find 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, we address the applicability of additional technologies and technical approaches that were discussed in the *NPRM*.

16. Third, we permit 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 discuss how our new rules for FDS devices relate to existing provisions for limited in-cabin aeronautical use. We also address matters related to compliance testing and use of equipment that currently operates under waivers of our existing rules.

A. Definitional Clarification and Mobile Use Expansion

17. *Definition of FDS/Radar.* In the *NPRM*, the Commission stated that, although Section 15.3(l) of our rules provides a definition for “field disturbance sensor,”³³ one must look to the general part

²⁹ See e.g., Robert Bosch LLC *ex parte* (filed Jan. 30, 2023); Joint *ex parte* from Acconeer AB, Intel Corporation, Meta Platforms Inc., and Qualcomm Incorporated (filed Nov. 10, 2022).

³⁰ Joint *ex parte* from radar proponents (represented by 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 communications proponents (represented by Intel Corporation, Meta Platforms Inc., and Qualcomm Incorporated) (filed Feb. 27, 2023) (Industry Consensus Agreement).

³¹ Joint *ex parte* from Acconeer, Intel, Meta Platforms, and Qualcomm (filed Nov. 10, 2022) (Pulse Radar Joint Agreement).

³² *Duty cycle* is defined as the ratio of the time-on time of a transmitter to the sum of the time-on and time-off times; Time-on / (Time-on + Time-off). See *Book/Definitions Electrical Engineering Dictionary*, Ed. Phillip A. Laplante Boca Raton: CRC Press LLC (2000).

³³ 47 CFR § 15.3(l) defines a field disturbance sensor as “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.” The part 15 definition for FDS sensors was adopted in 1971, in *Amendment of Part 15 of the Commission's Rules to Add Regulations Governing the Use of Field Disturbance Sensors (Formerly Designated as Radio Frequency Operated*

(continued....)

2 rules to find a definition for “radar.”³⁴ It asked whether the rules related to “field disturbance sensors” in section 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.³⁵

18. We clarify that radars are a sub-category of FDS as defined in both sections 15.3(l) and 2.1 of our rules.³⁶ We further find that the radar definition in section 2.1 of our rules is sufficiently broad when used in conjunction with the FDS definition of section 15.3(l) to accommodate the types of FDS applications envisioned for the 60 GHz band. We agree with both Texas Instruments (TI) and IEE Sensing that our 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,³⁷ and we find that modifying the definition in section 15.3(l) of the rules to include radars will achieve this objective. The final rules are set forth in Appendix B, *infra*.

19. *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.³⁸ The Commission further observed that a review of the 1998 Report and Order that first permitted fixed FDS use in the band suggests that the Commission was anticipating a narrow set of applications for industrial settings where the equipment would rarely if ever be moved.³⁹ In the *NPRM* in 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

Intruder Alarms), Docket No. 13863, FCC 71873, Report and Order, 31 FCC 2nd 210 (1971). The Commission did express that it “will interpose no objection to the operation of speed measuring equipment (or other radiolocation devices) under the regulations for field disturbance sensors...” while discussing radars in this context. *Id.*, at para. 21. In 1995, the Commission adopted the rules prohibiting FDS, specifically mobile FDS in 47 CFR § 15.255 in *Amendment of Parts 2, 15 and 97 of the Commission’s Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications*, ET Docket No. 94-124, FCC 95-499, First Report and Order, 11 FCC Rcd. 4481, 4496 (1995); in 2002, the Commission adopted rules for UWB radars in 47 CFR §§ 15.503, 15.515, specifically defining radars as FDS in *Revision of Part 15 of the Commission’s Rules Regarding Ultra-Wideband Transmission Systems*, ET Docket No. 98153, FCC 02-48, First Report and Order, 17 FCC Rcd 7435 (2002); in 2003, the Commission adopted rules for vehicular radars in 47 CFR § 15.252, specifically labeling vehicular radars as FDS in *Revision of Part 15 of the Commission’s Rules Regarding Ultra-Wideband Transmission Systems*, ET Docket No. 98-153, FCC 04-285, Second Report and Order, 19 FCC Rcd 24558 (2003).

³⁴ 47 CFR § 2.1 defines a radar as “a radiodetermination system based on the comparison of reference signals with radio signals reflected, or retransmitted, from the position to be determined”. This radar definition is taken from the International Telecommunication Union (ITU) Radio Regulations (RR).

³⁵ *NPRM*, 36 FCC Rcd at 11908, para. 17.

³⁶ 47 CFR §§ 15.3(l) and 2.1.

³⁷ TI Comments at 5; IEE Sensing Comments at 3.

³⁸ The general definitions in part 2 of our rules provide no guidance. Section 2.1 defines “Fixed Service” as “A radiocommunication service between specified fixed points,” which is not relevant to FDS operations.

³⁹ See *Revision of Part 15 of the Commission’s Rules Regarding Operation in the 57-64 GHz Band*, Third Report and Order, 13 FCC Rcd 15074 (1998). The current rule’s provision allowing the FDS move within the fixed equipment would support, for example a piece of large-scale industrial machinery located on a factory floor. See 47 CFR § 15.255(a)(2).

there is a bright line rule to differentiate fixed and mobile FDS operations.⁴⁰

20. Many commenters express support for eliminating the distinction between fixed and mobile FDS use or ask us to take an agnostic use case approach.⁴¹ Among the commenters that suggest specific definitions, Vayyar says that we 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.).⁴² 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,⁴³ 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.⁴⁴

21. We find 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, we conclude 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, we are not adding a specific “fixed” definition in our rules for unlicensed FDS devices..

22. For purposes of the 61.0-61.5 GHz ISM band segment, existing section 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.⁴⁵ 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.⁴⁶ 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 our decision to this band, we remove the “fixed” restriction applicable to FDS operation in section 15.255(c)(2). This is consistent with our intention to permit both fixed and mobile applications to be deployed within the entirety of the 60 GHz band.⁴⁷

23. *Removal of the SRIMS Designation.* Consistent with our decision to permit fixed and mobile radars to operate throughout the 60 GHz band, we adopt the proposal to remove the term “short-range interactive motion sensing” (SRIMS) from the rules. We acknowledge that there has been much

⁴⁰ *NPRM*, 36 FCC Rcd at 1197-18, para. 37 (proposing to retain Section 15.255(c)(2) but also seeking comment on whether this provision should be expanded to apply to both fixed and mobile FDS applications).

⁴¹ Amazon Comments at 11; *See also, e.g.*, Auto Innovators Comments at 5; TI Reply Comments at 3.

⁴² Vayyar Comments at 6-7.

⁴³ Google Comments at 23-24.

⁴⁴ Bosch Comments at 8.

⁴⁵ This band is also an Industrial, Scientific and Medical (ISM) frequency band. 47 CFR § 18.301.

⁴⁶ 47 CFR § 15.255(c)(2). This special provision was added in 1997 in *Amendment of Parts 2, 15, and 97 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications*, ET Docket No. 94-124, FCC 87-267, Memorandum Opinion and Order and Fourth Notice of Proposed Rulemaking, 12 FCC Rcd 12212 (1997).

⁴⁷ As described *infra*, we provide an option for use of the 57-64 GHz band under specified technical criteria, limited to fixed outdoor operations or vehicular applications, but believe that this use case is sufficiently discrete and clear in its application that it can be codified within Section 15.255(c)(2)(iii) without further detail.

confusion on which 60 GHz mobile and fixed radar applications qualify under the SRIMS designation,⁴⁸ and note that commenters unanimously supported the removal of the SRIMS terminology from the rules.⁴⁹ Because the FDS rules we are adopting herein will apply to all manners of fixed and mobile technologies operating under section 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, we remove this designation and associated relevant requirements from the rules.

B. Expanded Use of FDS Devices Operating in the 57-64 GHz band

24. In response to notice that the Commission was considering rules that would promote co-existence between communication devices—especially new immersive technologies⁵⁰—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 we are adopting balance the abilities of radar and communication devices to access the same spectrum. We adopt 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.⁵¹

25. Under our revised section 15.255 rules, which are set forth in Appendix B, we permit 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;⁵² (4) up to 14 dBm peak EIRP for all operations within the 57-64 GHz band subject to a 22.7% duty cycle;⁵³ and (5) up to 20 dBm peak EIRP for fixed outdoor operations or vehicular applications (except in-cabin vehicular use cases)⁵⁴ within the 57-64 GHz band subject to a 50% duty cycle.⁵⁵ In addition, for FDS devices that have a maximum pulse duration of 6 ns, we permit the following: a) the average EIRP shall not exceed 13 dBm and the transmit duty cycle shall not exceed 10% during any 0.3 μ s time window; b) the average integrated EIRP

⁴⁸ Many of the waiver requests filed with the Commission for higher power operation in section 15.255 argued that their devices are SRIMS to avoid asking for waiver of the definitional scope in 47 CFR § 15.255(a)(2), which prohibits mobile radars that do not qualify as SRIMS. *See, e.g., Valeo North America, Inc. Waiver Request*, ET Docket No. 20-121 (filed Mar. 31, 2020). We note that while the waivers focused on in-vehicle radar applications, the rules adopted herein will enable various radar applications, including other vehicular applications, such as the Garmin’s bicycle radar intended to detect objects in the rear of the bicycle to improve bicyclist safety. *See Garmin ex parte* (filed Sept. 26, 2022).

⁴⁹ Comments of Vayyar at 6, TI at 5, Infineon at 11, Google at 10-12, Amazon at 11.

⁵⁰ Immersive technologies create distinct experiences by merging the physical world with a digital or simulated reality. This is achieved by either using the technologies of Head-Mounted Display (HMD) or multiple projections.

⁵¹ Auto Innovators and Robert Bosch LLC are two parties outside of the signatories to the Agreement that have expressed support for the Industry Consensus Agreement. Auto Innovators *ex parte* at 2 (filed Apr. 3, 2023); Robert Bosch LLC *ex parte* (filed Apr. 13, 2023).

⁵² Specifically, the sum of continuous transmitter off-times of at least two milliseconds (ms) shall equal at least 16.5 ms within any contiguous interval of 33 ms.

⁵³ Specifically, the sum of continuous transmitter off-times of at least two ms shall equal at least 25.5 ms within any contiguous interval of 33 ms.

⁵⁴ “Fixed operation” under this use case applies to temporarily or permanently fixed operations. Vehicular uses include operations where the device is installed within or on the exterior of a vehicle intended for outdoor use (such that any indoor use is incidental – for example, an automobile in a parking garage) but excludes all in-cabin applications or operations. *See* Industry Consensus Agreement at fn. 4.

⁵⁵ Specifically, the sum of continuous transmitter off-times of at least two ms shall equal at least 16.5 ms within any contiguous interval of 33 ms.

within the frequency band 61.5-64.0 GHz shall not exceed 5 dBm in any 0.3 μ s time window; and c) peak emissions shall not exceed 20 dB above the maximum permitted average emission limit applicable to the equipment under test. We address unlicensed device use while airborne separately in Section III C, *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. We find 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 our simpler approach of having a single EIRP limit across the entire band as proposed in the *NPRM*. We note that these EIRP limits are lower than the limits permitted to general communication devices in the band.⁵⁶

1. Consensus Agreements

26. *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.⁵⁷ 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.⁵⁸ 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.⁵⁹

27. 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).⁶⁰ 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 this 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.

28. 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 2021,⁶¹ the

⁵⁶ Communication devices in the 57-71 GHz band are allowed up to 85 dBm peak EIRP in fixed point-to-point applications and up to 43 dBm peak EIRP in general multi-point networking applications. See 47 CFR §§ 15.255(c)(1)-(c)(2).

⁵⁷ The agreement is summarized in Appendix D, Table 1, Industry Consensus Agreement, *infra*.

⁵⁸ Meta is the new name for Facebook, effective Dec. 1, 2021. Facebook submitted comments in this proceeding under the name Facebook Inc. up to and including the year 2021. All Facebook comments were submitted subsequently under the new name Meta Platforms Inc.

⁵⁹ Industry Consensus Agreement from Amazon.com Services LLC, Continental Corporation, Garmin International, Inc., Google LLC, IEE Sensing Inc., Infineon Technologies Americas Corp., Intel Corporation, Meta Platforms Inc., Qualcomm Incorporated, Texas Instruments Incorporated, and Vayyar Imaging Ltd. (filed Feb. 27, 2023).

⁶⁰ The 60-64 GHz band partitioning for UA is discussed separately in Section III C.1, *infra*.

⁶¹ See *supra* n.18 (describing these waivers).

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 this proceeding, *supra*.⁶²

29. *Pulse Radar Joint Agreement.* Acconeer, the primary proponent for 60 GHz pulse radar technologies in our 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 we adopt these parameters into the rules.⁶³

30. 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."⁶⁴ 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.⁶⁵ 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.⁶⁶

31. *Discussion.* We find that the technical proposals included in the Industry Consensus Agreement in response to those on which the Commission sought comment provide a reasonable compromise that is well suited to foster our 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. We note 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.⁶⁷ Moreover,

⁶² See *ex parte* from Intel Corporation, Meta Platforms Inc., and Qualcomm Incorporated (filed May 31, 2022 and Aug. 19, 2022).

⁶³ Joint *ex parte* from Acconeer, Intel, Meta Platforms and Qualcomm (filed Nov. 10, 2022) (Pulse Radar Joint Agreement). The Industry Consensus Agreement states that its proposed regulatory framework is independent of the technology used by a radar system and is meant to be complementary to the Pulse Radar Joint Agreement and not an alternative to it. Industry Consensus Agreement at fn. 3. The agreement is summarized in Appendix D, Table 2, Pulse Radar Joint Agreement, *infra*.

⁶⁴ Acconeer Comments at 12.

⁶⁵ Acconeer Comments at 14.

⁶⁶ Acconeer Reply Comments at 8.

⁶⁷ Auto Innovators *ex parte* at 2 ("the [Industry Consensus Agreement] will help the auto industry to meet its commitment to make rear seat reminder systems standard equipment on almost all passenger vehicles sold in the United States by the 2025 model year") (filed Apr. 3, 2023). Robert Bosch LLC *ex parte* ("believes that the

(continued....)

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, our final rules draw favorably from this filing.

32. 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.⁶⁸ 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.⁶⁹ 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.⁷⁰ 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.⁷¹

33. To facilitate use by all technologies, we agree with Acconeer that because pulse radars necessitate wide bandwidths to accommodate their spread spectrum technique, we 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 this 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.⁷² By adopting technical parameters that are compatible with the Pulse Radar Joint Agreement, we 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 we are adopting also recognize the approach set forth in the Pulse Radar Joint Agreement.

2. Technical Considerations

34. *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.⁷³ 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

proposed rules in the 60 GHz band without timing constraints will enable the deployment of in-vehicle sensing functions which will coexist with other unlicensed users...” (filed Apr. 13, 2023).

⁶⁸ *NPRM*, 36 FCC Rcd at 11909, para. 19; *id.*, at 11909-10, para. 22.

⁶⁹ *NPRM*, 36 FCC Rcd at 11910, para. 24; *id.*, at 11913, para. 29; *id.*, at 11918-19, para. 38.

⁷⁰ *NPRM*, 36 FCC Rcd at 11913-14, paras. 30-31.

⁷¹ *NPRM*, 36 FCC Rcd at 11915-16, para. 33.

⁷² See e.g., Reply Comments from ITEM Inc., BrainLit AB, RelyQ LLC, NEXTY Electronics Corporation, Väderstad AB, Restar Electronics Americas Inc., Trickle Star Inc.

⁷³ Under ETSI, short-range devices (SRD) have a low risk of causing harmful interference to other radio services, usually because their transmitted power, and hence their range, is low.

at higher power limits in conjunction with a specified duty cycle.⁷⁴ 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.⁷⁵

35. 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,⁷⁶ 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.⁷⁷ Other parties addressed potential harmonization benefits in use of the 57-64 GHz band,⁷⁸ 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.⁷⁹ 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.⁸⁰ The radar industry initially opposed this approach.⁸¹

36. 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).⁸² 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 accounts 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

⁷⁴ *NPRM*, 36 FCC Rcd at 11909-10, paras. 21-22.

⁷⁵ *NPRM*, 36 FCC Rcd at 11915-16, para. 33.

⁷⁶ Google Comments at 14.

⁷⁷ Comments of Acconeer at 20, Amazon at 3-4.

⁷⁸ Valeo Comments at 6.

⁷⁹ WISPA Comments at 10.

⁸⁰ *See ex parte* from Intel Corporation, Meta Platforms Inc., and Qualcomm Incorporated (filed Aug. 19, 2022) (“proposing the following 3 operating modes: (a) a radar operating within the 57.0-59.0 GHz band may use up to 20 dBm peak EIRP, 13 dBm/MHz peak EIRP PSD, and without any duty cycle restriction; (b) a radar operating within the 57.0-61.5 GHz band may use up to 13 dBm peak EIRP, 13 dBm/MHz peak EIRP PSD, and a 10% duty cycle in every 33 ms interval; additionally, the radar operating with the 57.0-61.5 GHz band must include at least X ms of continuous silent time in every 2X ms interval, where X is between 2 and 10 ms; and (c) a radar operating within the 57-64 GHz band may use up to 13 dBm peak EIRP, 13 dBm/MHz peak EIRP PSD and a 10% duty cycle with at least 26.4 ms of continuous silence time in every 33 ms interval.”).

⁸¹ *See ex parte* from radar companies represented by Amazon.com Services LLC, Continental Corporation, Google LLC, IEE Sensing Inc., Infineon Technologies Americas Corp., and Texas Instruments Incorporated (filed Aug. 3, 2023). *But see* Robert Bosch LLC *ex parte* (filed Jan. 30, 2023) (proposing that we allow FDS to operate without any duty cycle restriction in the 57.24-61.56 GHz portion of the band, representing the first two WiGig channels).

⁸² A fourth partitioning (60-64 GHz) is also proposed specifically for operation on-board unmanned aircraft. This is further discussed in Section III C.1 On-board Aircraft Operation, *infra*.

would retard continued use and development of the band.⁸³ Therefore, we are adopting the soft segmentation plan as specified in the Industry Consensus Agreement.

37. *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.⁸⁴ 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,⁸⁵ 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.⁸⁶ 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,⁸⁷ or as in the case of Leica Geosystems AG, thin cables as small as 2.5 mm in diameter.⁸⁸

38. 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.⁸⁹ 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.⁹⁰ 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 we adopt a 13 dBm peak EIRP limit, the same as that granted in the waivers.⁹¹ 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.⁹² 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.⁹³

39. We find that the power limits endorsed in the Industry Consensus Agreement, represents

⁸³ The soft band segmentation framework is loosely built on the work started by the 60 GHz Co-existence Study Group. See *NPRM*, 36 FCC Rcd at 11915-16, para. 33.

⁸⁴ *NPRM*, 36 FCC Rcd at 11910, para. 24.

⁸⁵ All the 60 GHz waiver requests asked for 13 dBm EIRP, which is the same level we granted in the *Google Waiver*.

⁸⁶ *NPRM*, 36 FCC Rcd at 11910, para. 23.

⁸⁷ See, e.g., *Vayyar Imaging Ltd. Modification of Request for Limited Waiver of 47 CFR 15.255*, ET Docket 20-15 at 4 (filed May 5, 2020).

⁸⁸ *Leica Waiver Order* FCC Rcd at 7933-7934, para. 9. See also *supra* para 8 (discussing this waiver).

⁸⁹ See, e.g., Comments of Acconeer at 2, Amazon at 2, Infineon at 7.

⁹⁰ See, e.g., Acconeer Comments, Appendix A, Infineon Reply Comments at Appendix A and Enclosure, Google Comments at Appendices A-G, and Peraso Reply Comments.

⁹¹ FB *et al* at 15. See also Intel/Meta Platforms/Qualcomm (Intel *et al*) *ex parte* (filed Feb 16, 2022).

⁹² Blu Wireless comments at 4-5. See also "IEEE Draft Standard for Information Technology-Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks-Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications-Amendment 2: Enhanced Throughput for Operation in License-Exempt Bands Above 45 GHz," in *IEEE P802.11ay/D7.0*, pp.1-784, Dec. 11, 2020.

⁹³ Google Reply Comments at 7-8.

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. We agree 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, we note that operations that were permitted under our existing rules can continue under the revised rules and parties may continue operating under the IEEE 802.11ad protocol if they choose to. However, we find that there is a strong public benefit in expanding our rules to support the many innovative applications identified by the commenters, and that setting one power limit for all applications is not necessary.⁹⁴

40. We note 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.⁹⁵ We observe that in the *NPRM*, we 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.⁹⁶ 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, we are adopting the EIRP limits provided by Industry in the Industry Consensus Agreement and consistent with the analysis provided by the TIG.

41. *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.⁹⁷ The Commission proposed to require the same 10% duty cycle restriction associated with the multiple waiver grants⁹⁸ 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.⁹⁹

42. Radar proponents opposed a duty cycle requirement for FDS operations, stating that it

⁹⁴ See discussion in para. 25, *supra*.

⁹⁵ NTIA *ex parte* at 1-2 (filed June 21, 2022).

⁹⁶ *NPRM*, 36 FCC Rcd at 11913, para. 29.

⁹⁷ *Duty cycle* is defined as the ratio of the time-on time of a transmitter to the sum of the time-on and time-off times; Time-on / (Time-on + Time-off). See *Book/Definitions Electrical Engineering Dictionary*, Ed. Phillip A. Laplante Boca Raton: CRC Press LLC (2000).

⁹⁸ *NPRM*, 36 FCC Rcd at 11913-15, paras. 30-32.

⁹⁹ See *ex parte* from Google LLC and Facebook, Inc., ET Docket No. 18-70 (filed Sept. 7, 2018). Google agreed to the 3.3 ms duty cycle restriction after extensive consultation with Facebook and other stakeholders, as outlined in the above filing. However, in some of the waiver requests, parties had asked for a longer transmission time frame. See, e.g., Valeo Reply Comments, ET Docket No. 20-121 at 5 (rec. June 23, 2020); *Leica Geosystems AG's Request for Waiver of Part 15 of the Commission's Rules to Market a UAV Collision Avoidance Radar*, ET Docket No. 19-350 (filed Sept. 5, 2019) at 5.

would unnecessarily constrain the radars sensor's capabilities.¹⁰⁰ 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.¹⁰¹ 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.¹⁰²

43. 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.¹⁰³ 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.¹⁰⁴ 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, discussed *infra*) to allow for sufficient silent periods during which the spectrum may be accessed—or re-accessed—by communication devices.

44. 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."¹⁰⁵ 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,¹⁰⁶ which require very high data throughput and very low latency.¹⁰⁷ In their comments, radar interests claimed that such a rule would impair radar deployment and prevent their ability to meaningfully operate in the band.¹⁰⁸ 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

¹⁰⁰ See *e.g.*, Comments of Acconeer at 19, Amazon at 8-9, IEE Sensing at 6, Google at 17, and Husqvarna at 2. See also Bosch Comments at 6-7 (suggesting that we increase the duty cycle limit to 50% along with average power limit specified during the transmission cycle).

¹⁰¹ IEE Sensing Comments at 6. In an isochronous transmission, the sender and the receiver are synchronized in such a way that they send/receive during the same time slots.

¹⁰² Infineon Comments at 6. See also Rivieh Comments (stating that a lower duty cycle (*e.g.*, 10% at 33ms intervals) may be adequate for short-range motion detection use cases, but it is insufficient for building automation).

¹⁰³ FB *et al* Comments at 13.

¹⁰⁴ *Id.* at 12-13.

¹⁰⁵ *NPRM*, 36 FCC Rcd at 11914, para. 31.

¹⁰⁶ *Augmented Reality* (AR) is the digital creation of a fabricated set of objects that can be interspersed with real world elements, usually through a headset that overlays the objects on the lens, as the user also views their real surroundings. *Virtual Reality* (VR) is the digital creation of a fabricated immersive world, typically via a headset technology, that generates all the photons that the eye sees. *Extended Reality* (XR) refers to all real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables. See, *e.g.*, Y. Ghasempour, C. R. C. M. da Silva, C. Cordeiro and E. W. Knightly, "IEEE 802.11ay: Next-Generation 60 GHz Communication for 100 Gb/s Wi-Fi," in *IEEE Communications Magazine*, vol. 55, no. 12, pp. 186-192, Dec. 2017.

¹⁰⁷ *Throughput* is the rate of successful message delivery over a communication channel. *Latency* refers to how much time it takes for a signal to travel to its destination and back.

¹⁰⁸ See, *e.g.*, Google Comments at 17, Husqvarna Comments at 2, Valeo Comments at 8-9, Vayyar Comments at 6, and TI Comments at 11.

adopted.¹⁰⁹ 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.¹¹⁰ 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.¹¹¹

45. Based on the record, we conclude that a uniform duty cycle requirement as proposed in the *NPRM* will not promote our 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, we note 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 we have in this proceeding, we are adopting rules consistent with the provisions of those agreements.¹¹² Finally, we recognize that the final rules we are adopting do not follow the duty cycle requirements associated with the ETSI standards.

46. *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.¹¹³ It also sought input on whether the Commission 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.

47. We find that, based on the technical analyses submitted into the record,¹¹⁴ radars operating in this band typically use a relatively wide antenna beamwidth¹¹⁵ to detect scattered small objects and fine movements (e.g., chest movements on a patient, hand gestures, obstructive objects, etc.). We agree with Valeo¹¹⁶ and Vayyar¹¹⁷ that modern chip technologies for 60 GHz devices incorporate

¹⁰⁹ FB *et al* Comments at 12-13. Immersive virtual reality is a technology that aims to completely immerse the user inside the computer-generated world, giving the impression to the user that they have "stepped inside" the synthetic world. This is achieved by either using the technologies of Head-Mounted Display (HMD) or multiple projections. HMD allows VR to be projected right in front of the eyes and allows users to focus on it without any distraction.

¹¹⁰ *Ex parte* from Facebook, Inc., Intel Corporation, and Qualcomm Inc. in ET Docket No. 21-48 at 2 (filed May 10, 2021). *See also*, FB *et al* Comments at 13.

¹¹¹ Intel *et al ex parte*) at 3 (filed Aug. 19, 2022; Intel *et al ex parte* filings (filed Feb. 18, 2022 and May 2, 2022) (documenting testing purporting to show how a radar transmission can affect the latency of a virtual reality communications receiver).

¹¹² *See* para. 25, *supra* for a description of the duty cycle requirements for each band segment.

¹¹³ *NPRM*, 36 FCC Rcd at 11911-12, para. 26.

¹¹⁴ *See e.g.*, *FMCW Radar Interference with WiGig Communication Devices* from Peraso/Texas Instruments (filed Oct 15, 2021); Google Comments, Attachment A; Acconeer Comments at 30-39; Texas Instruments Comments at 6-8; *ex parte* from Qualcomm, Meta and Intel at 21-30 (filed Feb. 18, 2022).

¹¹⁵ Typically, this is 6 dBi or less, according to the radar technical analyses submitted into the record. In contrast, 60 GHz communications devices use up to 13-52 dBi antenna beamwidths. *See* 47 CFR § 15.255(c)(1).

¹¹⁶ Valeo Comments at 7.

¹¹⁷ Vayyar Comments at 8.

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 complied by calculations only, relying on the applicant's provided antenna gain information, thereby making such a requirement difficult to enforce. We also observe that the Industry Consensus Agreement suggests completely removing the conducted output power limit from FDS devices operating in the 57-64 GHz band. For these reasons, we decline to specify a conducted output power limit for FDS devices operating in the 57-71 GHz band. Similarly, we decline 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 without real countervailing benefits.¹¹⁸

48. *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.¹¹⁹ 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. We note that a power spectral density limit is not well matched to the nature of radar transmissions— which are in bursts, or chirps. Accordingly, we find 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 our proposal incompatible with that standard.¹²⁰ We also agree with Google¹²¹ that a power spectral density limit may be too restrictive for certain radar use cases with narrow bandwidths. We therefore will not adopt this requirement into the final rules.

49. *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.¹²² 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.¹²³ 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.¹²⁴ Other parties suggested that we could allow FDS devices to operate with power limits as high as those accorded

¹¹⁸ Preventing harmful interference is mainly driven by the EIRP limit, thus making a limit on conducted output power unnecessary, unless there is a need to ensure that the antenna gain is within a certain requirement in some cases.

¹¹⁹ *NPRM*, 36 FCC Rcd at 11912, para. 27.

¹²⁰ See Bosch Comments at 6, referencing EC Decision 2019/1345, available at <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019D1345>; See also IEE Sensing Comments at 8, Infineon Comments at 6.

¹²¹ Google Comments at 16.

¹²² See *2021 TAC Recommendation*. See also, *NPRM*, 36 FCC Rcd at 11918-19, para. 38.

¹²³ Acconeer Comments at 24. See also Valeo Comments at 6 and Vayyar Comments at 7 (identifying other potential disadvantages).

¹²⁴ WISPA Reply Comments at 7. See also Wi-Fi Alliance Comments at 13 (agreeing that using spectrum sensing technologies in the band could create co-existence problems).

to communication devices (i.e., up to 40 dBm EIRP) if they incorporated spectrum sharing techniques.¹²⁵

50. Given our decision to adopt final rules as described above, we see no need to further pursue the use of spectrum sensing technologies in the 60 GHz band at this time. Nothing in our 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.

C. Operation On-board Aircraft

51. In the *NPRM*, the Commission stated that it did not anticipate altering the existing restrictions in Section 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.¹²⁶ 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.¹²⁷ 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.¹²⁸

1. Operation on-board unmanned aircraft (UA)

52. 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.¹²⁹ 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 we have previously permitted via waiver to Leica Geosystems AG.¹³⁰ 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.¹³¹

¹²⁵ Google Comments at 18 and TI Comments at 14. *See also* Bosch Reply Comments at 9 (endorsing similar provisions, but only if compatibility studies yet to be conducted would produce results that indicate that LBT mitigation would be necessary).

¹²⁶ *NPRM*, 36 FCC Rcd at 11920, paras 42-43.

¹²⁷ 47 CFR § 15.255(b)(2).

¹²⁸ The two types of use cases thus far authorized are: 1) Leica Geosystems AG 60-64 GHz radar on an unmanned aircraft, but with very restrictive conditions on the number of deployed devices. *See Leica Waiver Order* FCC Rcd 7929; 2) Google Soli radar incorporated into a smartphone (e.g., the Google Pixel) allows control of a smartphone via gestures without touching the phone, and is not intended to be part of the aircraft communication network. *See Google LLC Request for Waiver of Section 15.255(c)(3) of the Commission's Rules Applicable to Radars used for Short Range Interactive Motion Sensing in the 57-64 GHz Frequency Band*, DA 18-1308, Order, 33 FCC Rcd 12542 (OET 2018).

¹²⁹ Amazon Comments at 12.

¹³⁰ *In the Matter of Leica Geosystems AG Request for Waiver of Section 15.255 of the Commission's Rules Applicable to Radars used on Unmanned Aerial Vehicles in the 60-64 GHz Frequency Band*, ET Docket No. 19-350, DA 20-795, Order, FCC Rcd 7929 (OET 2020).

¹³¹ Amazon *ex parte* at 1 (filed Sep. 13, 2022); *id.*, at 1 (filed Nov. 1, 2022); *id.*, at 1 (filed Dec. 19, 2022); *id.*, at 2 (filed Mar. 20, 2023).

53. Over the course of the rulemaking, we 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."¹³² 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.¹³³

54. We find 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, our strict out-of-band limits in the rules already prevent any increase in potential harmful interference caused by the device's operation."¹³⁴ 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.¹³⁵ 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.¹³⁶ We agree 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, we find 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. We also note that the Federal Aviation Administration (FAA) part 107 rules limit operation of small unmanned aircraft to 121.92 meters (400 feet) AGL.¹³⁷ The rules we are 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.

55. *Power Levels.* With respect to power levels for FDS devices operating on UA, we note that the Industry Consensus Agreement proposes such operations be limited to 20 dBm peak EIRP with a 50% duty cycle.¹³⁸ 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

¹³² GAMA *ex parte* at 1 (filed Nov. 14, 2022).

¹³³ Joint *ex parte* comment from the Consumer Technology Association, CTIA, Information Technology Industry Council (ITI), NetChoice, TechNet, and U.S. Chamber of Commerce (filed Dec. 16, 2022).

¹³⁴ *Leica Waiver Order*, 35 FCC Rcd at 7933, para. 7.

¹³⁵ *Leica Waiver Order*, 35 FCC Rcd at 7933, para. 8.

¹³⁶ *Leica Waiver Order*, 35 FCC Rcd at 7932, para. 6. We note that mobile use minimizes the potential for harmful interference by its very nature of moving about, whereas fixed use is more susceptible if an interferer signal is located in its antenna beam.

¹³⁷ 14 CFR § 107.51.

¹³⁸ Specifically, the sum of continuous transmitter off-times of at least two ms shall equal at least 16.5 ms within any contiguous interval of 33 ms.

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.¹³⁹ Accordingly, we are 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.

2. Operation on-board aircraft other than UA

56. As indicated above, Section 15.255(b)(2) prohibits operation on aircraft, unless the device is part of "closed exclusive on-board communication networks within the aircraft."¹⁴⁰ 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.¹⁴¹ In the *NPRM*, the Commission noted that compliance options exist for portable electronic devices¹⁴² that may be brought aboard airplanes; these could include, for example, requiring "airplane mode" to be activated during flight.

57. 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.¹⁴³ 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,¹⁴⁴ and requests that we do not expand airborne use of radars.¹⁴⁵ 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."¹⁴⁶

58. 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.¹⁴⁷

59. We recognize and support the vital interest in protecting the passive EESS services in the

¹³⁹ NTIA *ex parte* (filed June 21, 2022).

¹⁴⁰ This refers to entertainment systems that deliver movies and music to passengers on-board commercial aircraft. 47 CFR § 15.255(b).

¹⁴¹ See *Google LLC Request for Waiver of Section 15.255(c)(3) of the Commission's Rules Applicable to Radars used for Short Range Interactive Motion Sensing in the 57-64 GHz Frequency Band*, DA 18-1308, Order, 33 FCC Rcd 12542 (2018).

¹⁴² *NPRM*, 36 FCC Rcd at 11919.

¹⁴³ CORF Comments at 13.

¹⁴⁴ CORF Comments at 15-16.

¹⁴⁵ FARS Reply Comments at 1-2.

¹⁴⁶ Google Reply Comments at 10. The Google Soli Radar operates under waiver in the 57-64 GHz band, which includes the EESS passive 57-59.3 GHz band.

¹⁴⁷ NTIA *ex parte* at 1-2 (filed June 21, 2022).

57.0-59.3 GHz band. We also acknowledge 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. We 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 smart phones, laptop computers, etc. These radar operations would not need to be part of the on-board communication system within the aircraft.¹⁴⁸

D. Implementation Considerations

1. Compliance Testing

60. In the *NPRM*, the Commission proposed to exempt FMCW and other similar swept-frequency radars from the section 15.31(c) requirement to stop the frequency sweep when measuring the relevant technical parameters.¹⁴⁹ The Commission explained that stopping the sweep is physically impractical for most of these devices and can result in inaccurate measurements.¹⁵⁰ In addition, the Commission proposed to remove the section 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 section 15.255(i),¹⁵¹ 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 section 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.¹⁵² 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.¹⁵³

61. 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 5.6.¹⁵⁴ Bosch argues that this is the only feasible option for measuring the total radiated power of FDS devices.¹⁵⁵ 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 floor 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.¹⁵⁶ Infineon states that, given that the goal is to establish an average EIRP for purposes of increased compatibility with other 60 GHz Band

¹⁴⁸ 47 CFR § 15.255(b)(2) (operation on aircraft is permitted while airborne only in closed exclusive communication networks within the aircraft).

¹⁴⁹ 47 CFR § 15.31(c).

¹⁵⁰ An FMCW radar works by sweeping a continuous wave (CW) signal over a defined frequency range. If the sweep is stopped for a bandwidth measurement, the measured bandwidth will be that of a CW signal, which is zero.

¹⁵¹ 47 CFR § 15.255(i) states "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."

¹⁵² 47 CFR § 15.35(c).

¹⁵³ Garage door openers typically operate in the 300-390 MHz frequency range.

¹⁵⁴ Bosch suggests that the total radiated power may be measured and assessed as described in ETSI EN 303 883-1 Version 1.2.1 clause 5.6 equation 20 and figure 10. Bosch comments at 6. See *Short Range Devices (SRD) and Ultra-Wide Band (UWB); Part 1: Measurement techniques for transmitter requirements*, ETSI EN 303 883-1 V1.2.1 (2021-02), at https://www.etsi.org/deliver/etsi_en/303800_303899/30388301/01.02.01_60/en_30388301v010201p.pdf.

¹⁵⁵ Bosch Comments at 6.

¹⁵⁶ Acconeer Comments at 20.

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.¹⁵⁷ 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.¹⁵⁸ Vayyar supports removing the requirement that the sweep is stopped during parts of the compliance testing.¹⁵⁹ 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.¹⁶⁰

62. We find that exempting FMCW and other swept-frequency radars from section 15.31(c) is necessary for performing meaningful compliance measurements.¹⁶¹ In addition, we find it appropriate to remove section 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.¹⁶² Further, section 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, we find that the provision of section 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. We disagree with Bosch's suggestion to consider TRP instead of EIRP. TRP measurements require substantial sampling over the 4π steradian space,¹⁶³ thus leading to significant complications in performing compliance measurements.¹⁶⁴ 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, we agree with Valeo that the occupied bandwidth be measured as part of the compliance measurements. Doing so will ensure fidelity to the requirements specified in section 2.1049 as required by section 15.201(b).¹⁶⁵ We disagree 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

¹⁵⁷ Infineon Reply Comments at 10.

¹⁵⁸ Valeo Comments at 9.

¹⁵⁹ Vayyar Comments at 8.

¹⁶⁰ Auto Innovators Comments at 3.

¹⁶¹ An FMCW radar transmitter develops its emission bandwidth by sweeping over a defined set of frequencies. In order to measure the associated bandwidth, the device must sweep normally. If the sweep is stopped, then the measured bandwidth will be that of the continuous wave (CW) signal, which is theoretically zero.

¹⁶² Section 15.255(c)(4) requires that the RF detector used for compliance measurements have a video bandwidth of at least 10 megahertz.

¹⁶³ A steradian is a unit of solid-angle measure in the International System of Units (SI), and is related to the surface area of a sphere in the same way a radian is related to the circumference of a circle.

¹⁶⁴ This methodology was first proposed to accommodate multi-element array antennas (i.e., massive multiple-input, multiple output (MIMO)) that can form multiple beams and employ electronic beam steering. It is a technology typically used to support point-to-multipoint operations (e.g., 5G cellular); however, the short-range radars under consideration in this rulemaking will almost certainly not be using such antenna technology due to size and expense.

¹⁶⁵ 47 CFR §§ 2.1049 and 15.201(b).

will permit the measurement of occupied bandwidth, even in a radiated measurement, with adequate sensitivity.

2. Operation of Equipment Subject to Prior Waivers and Transition Provisions

63. As noted above, a number of parties have been granted waivers of certain provisions of section 15.255 to permit operation of innovative radar devices in the 60 GHz band.¹⁶⁶ 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 our modified rules.¹⁶⁷ The Commission proposed to terminate all previously granted 60 GHz FDS waivers and FDS device manufacturers would be expected to conform their operations to our rules as revised.¹⁶⁸

64. 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.¹⁶⁹ The Industry Consensus Agreement suggests a six-month transition period applicable only to new certifications under the terms of the waivers.¹⁷⁰ 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.¹⁷¹

65. We agree 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 we also want 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. We agree 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, we 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 this proceeding must comply with the new rules.¹⁷² We terminate the 60 GHz band waivers that are currently in effect at the conclusion of this transition period. However, we specify that so long as a 60 GHz FDS/radar does not cause harmful interference, it can continue to operate until

¹⁶⁶ See *supra* para. 8.

¹⁶⁷ See, e.g., *60 GHz Vehicle Radar Waiver*, *supra* n.131 at para. 52 (“We note that operations pursuant to the waivers we grant today are expressly conditioned on compliance with the Commission’s rules except as waived, and where rules are modified as a result of any future Commission rulemaking these operations will be subject to those modified rules”); Vayyar *ex parte*, ET Docket No. 21-15 at 1 (noting that Vayyar “was fully aware of the anticipated 60 GHz rulemaking proceeding and fully understood and agreed that any waiver granted to Vayyar would be subject to future alignment with the outcome of such rulemaking”) (filed June 1, 2021).

¹⁶⁸ *NPRM*, 36 FCC Rcd at 11908-09, para. 18.

¹⁶⁹ Comments from Auto Innovators at 6, Amazon at 4, Google at 24, and IEE Sensing at 12.

¹⁷⁰ Industry Consensus Agreement at 3.

¹⁷¹ Pulse Radar Joint Agreement at 1-2. In asking for extended period, the parties stated that Acconeer’s waiver “provides for more restrictive operations than the technical parameters proposed [in the Pulse Radar Joint Agreement] and is limited to certain vehicular use cases.” *Id.*

¹⁷² All 60 GHz devices are approved by TCBs rather than the Commission. When a TCB approves a device, the Commission is notified only after the approval rather than when the applicant files an application for certification. Accordingly, we are specifying transition dates based on when a TCB approves a device rather than on when a party files an application for certification. During the transition period, TCBs may continue to approve devices that comply with the terms of the existing waivers even if they do not meet the terms of the new rules.

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.

IV. PROCEDURAL MATTERS

66. *Regulatory Flexibility Act.* The Regulatory Flexibility Act of 1980, as amended (RFA),¹⁷³ 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.”¹⁷⁴ Accordingly, we have prepared a Final Regulatory Flexibility Analysis (FRFA) concerning the possible impact of the rule changes and/or policy contained in this Report and Order on small entities. The FRFA is set forth in Appendix C.

67. *Congressional Review Act.* [The Commission will submit this draft *Report & Order* to the Administrator of the Office of Information and Regulatory Affairs, Office of Management and Budget, for concurrence as to whether this rule is “major” or “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).

68. *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).

V. ORDERING CLAUSES

69. 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), 302, 303(b), (c), (e), (f), (r), 307, this *Report and Order* IS HEREBY ADOPTED.

70. IT IS FURTHER ORDERED that Part 15 of the Commission’s rules IS AMENDED as specified in Appendix B, and such rule amendments WILL BECOME EFFECTIVE 30 days after the date of publication in the *Federal Register*.

71. 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 operate under waiver prior to the effective date of the rule amendments adopted herein MAY CONTINUE TO OPERATE so long as such operations are consistent with the terms of the *Report and Order*.

72. 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.

73. 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).

¹⁷³ 5 U.S.C. §§ 601–612. The RFA has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

¹⁷⁴ 5 U.S.C. § 605(b).

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

APPENDIX A
List Of Commenters

Comments

Acconeer AB
ADC Automotive Distance Control Systems GMBH
Advocates for Highway and Auto Safety
Alliance for Automotive Innovation
Alps Alpine Co., Ltd.
Amazon.com, Inc.
Automotive Safety Council (ASC)
Axis Communications
Blu Wireless, Inc.
Facebook, Intel, and Qualcomm Incorporated
Google LLC
Husqvarna AB
IEE Sensing Inc.
Infineon Technologies Americas Corp.
Inxpect SPA
Motor and Equipment Manufacturers Association (MEMA)
National Academy of Sciences' Committee On Radio Frequencies (CORF)
National Telecommunications and Information Administration (NTIA)
Nexty Electronics Corporation (Nexty)
Rivieh, Inc.
Robert Bosch LLC
Texas Instruments Incorporated
Valeo North America, Inc.
Vayyar Imaging Ltd.
WI-FI Alliance

Reply Comments

Acconeer AB
ADC Automotive Distance Control Systems GMBH
Alliance for Automotive Innovation (Auto Innovators)
Alps Alpine Co., Ltd.
Apple Inc.
Axis Communications AB
Banner Engineering Corporation
BrainLit AB
CODICO
Consumer Technology Association (CTA)
Digi-Key
Eleven-x Inc.
Facebook Inc., Intel Corporation, and Qualcomm Incorporated
Force Five Inc.
Frequency Allocation in Remote Sensing (FARS) Technical Committee

Google LLC
Groove X, Inc.
Hosiden Corporation
IEE Sensing Inc.
IEEE 802 LAN/MAN Standards Committee (LMSC)
Imagimob AB
Indesmatech ApS
Infineon Technologies Americas Corp. (Infineon)
Intelligent Traffic Equipment Marketing Ltd. (ITEM Ltd.)
JulyMonster Inc.
MicroSummit K.K.
Motor and Equipment Manufacturers Association (MEMA)
OSM Group
Packwise GmbH
PERASO
relyQ LLC
Restar Electronics Americas Inc.
Robert Bosch LLC
Sleepiz AG
Spop Tech, Inc.
TecaHEAD Incorporated
Tekelek Ltd
Texas Instruments Incorporated
TrickleStar, Inc.
Väderstad AB
Vayyar Imaging Ltd.
Vtech Telecommunications Ltd.
Wireless Internet Service Providers Association
Zektur AB

Ex parte Comments

Acconeer AB
ACT | The App Association
Advocates for Highway and Auto Safety
The Alliance for Automotive Innovation
Amazon.com Services LLC
Apple Inc.
Blumio, Inc.
Consumer Technology Association (CTIA)/ Information Technology Industry Council (ITI)/
Continental Corporation
Garmin International, Inc.
General Aviation Manufacturing Association
Global Sunrise Marketing LLC (dba Greenworks)
Google LLC Infineon Technologies Americas Corp.
Inxpect SPA
Joint Acconeer AB, Amazon.com Services LLC, Google LLC, Infineon Technologies Americas Corp., and Texas Instruments Incorporated
Joint Acconeer AB, Intel Corporation, Meta Platforms Inc., and Qualcomm Incorporated

Joint Amazon.com, Inc., Apple Inc., Continental Corporation, Google LLC, Infineon Technologies Americas Corp. and Texas Instruments Incorporated

Joint Amazon.com Services LLC, Continental Corporation, Garmin International, Inc., Google LLC, IEE Sensing Inc., Infineon Technologies Americas Corp., Intel Corporation, Meta Platforms Inc., Qualcomm Incorporated, Texas Instruments Incorporated, and Vayyar Imaging Ltd.

Joint Amazon.com Services LLC, Continental Corporation, Google LLC, IEE Sensing, Inc., Infineon Technologies Americas Corp. and Texas Instruments Incorporated

Joint Amazon.com Services LLC, Google LLC, IEE Sensing, Inc., Infineon Technologies Americas Corp., Texas Instruments Incorporated and Vayyar Imaging Ltd.

Joint Association for Uncrewed Vehicle Systems International (AUVSI), Commercial Drone Alliance (CDA) and Small UAV Coalition

Joint Information Technology and Innovation Foundation /Open Technology Institute at New America/ R Street Institute/ Public Knowledge/ American Action Forum

Joint Intel Corporation, Meta Platforms Inc. and Qualcomm Incorporated

Joint NetChoice/ TechNet/ U.S. Chamber of Commerce

Lenovo (United States) Inc.

Magic Leap Inc.

New America's Open Technology Institute

Robert Bosch LLC

Sunrise Global Marketing, LLC dba Greenworks Tools

Tellus You Care, Inc.

Texas Instruments Incorporated

Wingtra AG

APPENDIX B
Final Rules

Part 15 of Title 47 of the Code of Federal Regulations is amended as follows:

PART 15 – RADIO FREQUENCY DEVICES

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.

1. Section 15.3(l) is revised 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 devices in 47 CFR § 2.1 is an example of a field disturbance sensor.

* * * * *

2. Section 15.31 is amended 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.

* * * * *

3. Section 15.35 is amended 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.

* * * * *

4. Section 15.37 is amended by adding a new paragraph (r) to read as follows:

§ 15.37 Transition provisions for compliance with this part.

* * * * *

(r) Field disturbance sensor/radar devices 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 operate in accordance with their certifications. All other field disturbance sensor/radar devices shall comply with the requirements in § 15.255 of this part.

* * * * *

5. Section 15.255 is amended by adding a title to paragraphs (b), (g), and (h), revising paragraph (a) and removing paragraphs (a)(1) and (a)(2); amending paragraph (b) by revising paragraph (b)(2)(ii), adding paragraphs (b)(2)(iii) and (b)(3); amending paragraph (c) by revising the introductory sentence, and revising paragraphs (c)(1)-(c)(4); amending paragraph (e) by revising the introductory paragraph, adding paragraphs (e)(1) and (e)(2), and removing paragraph (e)(3); and revising paragraph (i), and adding paragraphs (i)(1) and (i)(2) to 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.* * * *

(1) * * *

(2) * * *

(i) * * *

(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)-(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:

(i) * * *

(ii) * * *

(2) Field disturbance sensors/radars shall not exceed 10 dBm peak EIRP except that field disturbance sensors/radars that limit their operation to all or part of the specified frequency band may comply with 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: 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 that for devices employed for either temporary or permanently fixed outdoor operation or vehicular uses (excluding in-cabin applications and operations), 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;

(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 μ s 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 μ s 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) of this part 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 (c)(3) of this section.

(d) * * *

* * *

(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.

* * * * *

APPENDIX C

Final Regulatory Flexibility Analysis

1. As required by the Regulatory Flexibility Act of 1980, as amended (RFA),¹ an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the *Notice of Proposed Rulemaking (NPRM)* released in July 2021 in this proceeding.² The Commission sought written public comment on the proposals in the *NPRM*, including comment on the IRFA. No comments were filed addressing the IRFA. This present Final Regulatory Flexibility Analysis (FRFA) conforms to the RFA.³

A. Need for, and Objectives of, the Report and Order

2. This *Report and Order* revises section 15.255 of the Commission's 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 and with passive sensors in the 57.0-59.3 GHz Earth Exploration Satellite Service (EESS) band. The final rules set forth distinct technical and operational provisions for 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 aeronautical vehicles. 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.

3. Specifically, the Report and Order: 1) clarifies the relationship between radars and FDS applications and modifies the 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 currently permitted but only for fixed use; 2) permits various EIRP levels along with specific duty cycle restrictions related to specific segmentations of the band for FDS devices that limit their operating frequencies to the 57-64 GHz portion of the 57-71 GHz band. The Report and Order found that these distinctions offer the best opportunity for new and existing unlicensed devices to successfully co-exist in the 60 GHz band; 3) 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 our new rules for FDS devices relate to existing provisions for limited in-cabin aeronautical use; and 4) addresses matters related to compliance testing and use of equipment that currently operates under waivers of the existing rules.

B. Summary of Significant Issues Raised by Public Comments in Response to the IRFA

4. There were no comments filed that specifically addressed the proposed rules and policies presented in the IRFA.

C. Response to Comments by the Chief Counsel for Advocacy of the Small Business Administration

5. Pursuant to the Small Business Jobs Act of 2010, which amended the RFA, the Commission is required to respond to any comments filed by the Chief Counsel for Advocacy of the Small Business Administration (SBA), and to provide a detailed statement of any change made to the proposed rules as a result of those comments.⁴

¹ See 5 U.S.C. § 603. The RFA, see 5 U.S.C. §§ 601-612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996, (SBREFA) Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

² *Amendment of Section 15.255 of the Commission's Rules*, ET Docket Nos. 21-264, Notice of Proposed Rulemaking, 36 FCC Rcd. 11901 (July 14, 2021) (*NPRM*).

³ See 5 U.S.C. § 604.

⁴ *Id.* § 604 (a)(3).

6. The Chief Counsel did not file any comments in response to the proposed rules in this proceeding.

D. Description and Estimate of the Number of Small Entities to Which the Proposed Rules Would Apply

7. The RFA directs agencies to provide a description of, and where feasible, an estimate of the number of small entities that may be affected by the rules adopted herein.⁵ The RFA generally defines the term “small entity” as having the same meaning as the terms “small business,” “small organization,” and “small governmental jurisdiction.”⁶ In addition, the term “small business” has the same meaning as the term “small business concern” under the Small Business Act.⁷ A “small business concern” is one which: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the SBA.⁸

8. *Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing.* This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment.⁹ Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and broadcasting equipment.¹⁰ The SBA small business size standard for this industry classifies firms having 1,250 employees or less as small.¹¹ U.S. Census Bureau data for 2017 show that there were 656 firms in this industry that operated for the entire year.¹² Of this number, 624 had fewer than 250 employees.¹³ Based on this data, we conclude that a majority of manufacturers in this industry are small.

E. Description of Projected Reporting, Recordkeeping, and Other Compliance Requirements for Small Entities

9. As there is insufficient data on the record, the Commission cannot, at present, definitively quantify the cost of recordkeeping, reporting or other forms of compliance and cannot determine whether small entities will have to hire attorneys, engineers, consultants or other professionals to comply with the rules adopted in the *Report and Order*; however, we sought comment on any steps that could be taken to minimize any significant economic impact on small businesses. No comments were received on this

⁵ *Id.* § 604(a)(4).

⁶ *Id.* § 601(6).

⁷ *Id.* § 601(3) (incorporating by reference the definition of “small-business concern” in the Small Business Act, 15 U.S.C. § 632). Pursuant to 5 U.S.C. § 601(3), the statutory definition of a small business applies “unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register.”

⁸ 15 U.S.C. § 632.

⁹ See U.S. Census Bureau, *2017 NAICS Definition*, “334220 Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing,” <https://www.census.gov/naics/?input=334220&year=2017&details=334220>.

¹⁰ *Id.*

¹¹ See 13 CFR § 121.201, NAICS Code 334220.

¹² See U.S. Census Bureau, *2017 Economic Census of the United States, Employment Size of Firms for the U.S.: 2017*, Table ID: EC1700SIZEEMPFIEM, NAICS Code 334220, <https://data.census.gov/cedsci/table?y=2017&n=334220&tid=ECNSIZE2017.EC1700SIZEEMPFIEM&hidePrevious=false>.

¹³ *Id.* The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard.

issue.

10. Radars operating in the 60 GHz band are required to be authorized under the Commission's certification procedure as a prerequisite to marketing and importation, and the rules adopted in the *Report and Order* have no impact on that requirement. We believe that this rulemaking, by expanding the flexibility of unlicensed FDS devices in the 60 GHz band, will provide an advantage to small entities, as these entities will benefit from being able to access this spectrum without the complication or cost of needing to obtain a license by operating FDS devices in other frequency bands. On balance, we believe this will constitute a significant benefit for small businesses.

F. Steps Taken to Minimize the Significant Economic Impact on Small Entities, and Significant Alternatives Considered

11. The RFA requires an agency to provide, “a description of the steps the agency has taken to minimize the significant economic impact on small entities...including a statement of the factual, policy, and legal reasons for selecting the alternative adopted in the final rule and why each one of the other significant alternatives to the rule considered by the agency which affect the impact on small entities was rejected.”¹⁴

12. The rule changes in the *Report and Order* for higher power to field disturbance sensors and radars will provide greater flexibility to 60 GHz device operations by expanding the permissible uses for short-range radars in the 57 to 64 GHz band while promoting coexistence with other unlicensed users, and not interfering with licensed and authorized users in the band. As these rule changes provide greater flexibility, they may benefit small entities in multiple ways. For example, since the operation of 60 GHz devices do not require a license, small entities are able to operate 60 GHz devices without the cost or inconvenience of obtaining a license. Moreover, with the rule changes, small entities will be able to operate new types of equipment, FDS/radars, at higher power, thus enabling additional applications, bringing multiple consumer benefits.

13. Throughout the comment cycle, the Commission was asked to consider numerous views from small and other entities on matters reflecting longstanding disagreements amongst various industry segments regarding equitable spectrum access. For example, disagreements emerged between radar proponents and communication proponents, with parties from each group opposing different aspects of the proposals concerning power levels and duty cycles/radar transmission off-times based on different segmentations of the 57-64 GHz band. We considered all proposals raised by the various commentors as potential alternatives to the proposed rule. However, given the wide ranging differences in opinion amongst the various commenters, the Commission sought to minimize the significant economic impact on small entities by seeking common ground and compromise amongst the disparate parties. We feel this has been largely achieved in the *Report and Order* through the Industry Consensus Agreement submitted on February 27, 2023 that addresses the interests of both FMCW radars and communications devices,¹⁵ and via a separate Pulse Radar Joint Agreement submitted on November 10, 2022 that describes technical parameters suitable for pulse radar operations.¹⁶

14. While any rule changes come with some potential burden, we believe that the rule changes that we are implementing in the *Report and Order* are necessary in order to ensure that the public

¹⁴ 5 U.S.C. § 604(a)(6).

¹⁵ Joint *ex parte* from radar proponents (represented by 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 communications proponents (represented by Intel Corporation, Meta Platforms Inc., and Qualcomm Incorporated) (filed Feb. 27, 2023) (Industry Consensus Agreement).

¹⁶ Joint *ex parte* from Acconeer, Intel, Meta Platforms, and Qualcomm (filed Nov. 10, 2022) (Pulse Radar Joint Agreement).

receives the benefits of innovative products and technologies in a prompt and efficient manner.

G. Report to Congress

15. The Commission will send a copy of the *Report and Order*, including this FRFA, in a report to be sent to Congress pursuant to the Congressional Review Act.¹⁷ In addition, the Commission will send a copy of the *Report and Order*, including this FRFA, to the Chief Counsel for Advocacy of the SBA. A copy of the *Report and Order* and FRFA (or summaries thereof) will also be published in the Federal Register.¹⁸

¹⁷ 5 U.S.C. § 801(a)(1)(A).

¹⁸ See 5 U.S.C. § 604(b).

APPENDIX D

Tables Of Technical Parameters

Table 1 – Industry Consensus Agreement

Mode	Frequency Range	Use Cases	Power Limit (Peak EIRP)	Off Time Requirement: off times (≥ 2 ms) must sum to at least X ms per 33 ms interval
Field disturbance sensors excluding outdoor drones /UA (i.e., unmanned aircraft – see below)	57.0 - 59.4 GHz	All	20 dBm for indoor 30 for outdoor, including all vehicular, applications	None
	57.0 - 61.56 GHz	All	3 dBm	None
	57.0 - 61.56 GHz	All	20 dBm	16.5 ms off time per 33 ms
	57.0-64.0 GHz	All	14 dBm	25.5 ms off time per 33 ms
	57.0-64.0 GHz	Fixed outdoor or vehicular uses (except in-cabin) ⁴	20 dBm	16.5 ms off time per 33 ms
Outdoor drones/UA	60-64 GHz	Drones/UA	20 dBm	16.5 ms off time per 33 ms

NOTES:

- Switching between requirements in frequency ranges is allowed in successive 33 ms frames (for example, operation in the 57-61.56 GHz band under applicable parameters in the first 33 ms frame followed by operation in the 57-64 GHz band under applicable parameters in the second 33 ms frame, *etc.*).
- No separate duty cycle requirements are imposed on active 60 GHz transmitters beyond what is stated in the right-most column.
- Fixed operation includes temporarily or permanently fixed operations. Vehicular uses include operations where the device is installed within or on the exterior of a vehicle intended for outdoor use (such that any indoor use is incidental – for example, an automobile in a parking garage) but excludes all in-cabin applications or operations.

Table 2 – Pulse Radar Joint Agreement

Technical Parameter ⁵	Permissible Pulse Radar Operations
Operating frequency high	64 GHz
Operating frequency low	57 GHz
Duty cycle	10%, evaluated in any 0.3 μ s time window
Average EIRP	13 dBm, evaluated in any 0.3 μ s time window, and the average integrated EIRP within 61.5 to 64.0 GHz shall not exceed 5 dBm in any 0.3 μ s time window
Pulse duration	< 6 ns
Peak EIRP	Peak RF emissions must not exceed 20 dB greater than the maximum permitted average emission limit applicable to the equipment under test