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**Instituto Federal de Telecomunicaciones**

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Respecto al asunto de:
Consulta Pública sobre el "Anteproyecto de Acuerdo mediante el cual el Pleno del Instituto Federal de Telecomunicaciones actualiza las condiciones técnicas de operación para el uso de la banda de frecuencias 57-64 GHz, clasificada como espectro libre"

# COMENTARIOS DE ACCONEER AB


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## TABLA DE CONTENIDO

**COMENTARIOS DE ACCONEER AB**

Acconeer AB ("Acconeer") respalda los esfuerzos del Instituto Federal de Telecomunicaciones ("IFT") para expandir la flexibilidad operacional de la banda 57-64 GHz ("60 GHz").[1/] Acconeer ha desarrollado un sensor de radar operando en 57-64 GHz, proporcionando una gran variedad de casos de uso que sirven un número de sectores industriales. Acconeer tiene muchos clientes que tienen la intención de comercializar la solución de un radar pulsado innovativo para un número de funciones mundiales.

Además, dado que estos clientes diseñan y venden sus productos en una base global, es vital que se adopten reglas en México que armonicen productos con reglas y estándares ya en uso en el mundo entero. Por estas razones, sería de interés público para el IFT de adopter nuevas reglas para 60 GHz para sensores de perturbaciones de campo (comúnmente conocidos como "radar") consistentes con el estándard ETSI ya vigente en la mayoría de los países del mundo.[2/]

**ANTECEDENTES**

**A. Introducción**

Acconeer es una empresa de desarrollo de sensores de radar ubicada en Malmö, Suecia. Acconeer fue fundada en 2011 para desarrollar nuevas tecnologías basadas en investigaciones iniciadas en la Universidad de Lund, listada en Nasdaq First North en 2017. Acconeer es un

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1/ Anteproyecto de Acuerdo mediante el cual el Pleno del Instituto Federal de Telecomunicaciones actualiza las condiciones técnicas de operación para el uso de la banda de frecuencias 57-64 GHz, clasificada como espectro libre ("Anteproyecto de Acuerdo"), publicado por IFT el 24 de febrero de 2022.

2/ *Véase p.ej.*, Electronic Comm. Committee, *ERC Recommendation 70-03*, 44-48 (2021), https://docdb.cept.org/download/25c41779-cd6e/Rec7003e.pdf.

precursor en el desarrollo de pequeños sistemas de radar eficientes en energía y costos que van a posibilitar un futuro más seguro y sostenible.

Acconeer ha desarrollado un sensor de radar pulsado coherente de 60 GHz que tiene las ventajas de producirse en un espacio compacto (*p.ej.* 5x5x0.8 mm) consumiendo bajas cantidades de energía. El uso de la banda 60 GHz permite al sensor de radar de Acconeer detectar variaciones extremadamente pequeñas en el ambiente local como signos vitales de un ser humano, utilizando antenas pequeñas que permiten la integración del sensor en un espacio pequeño.

El sistema de radar de Acconeer puede usarse en una gran variedad de aplicaciones tales como sistemas fijos que detecten la presencia de personas dentro de edificios y vehículos y dispositivos móviles alimentados por batería como teléfonos móviles, portátiles, relojes inteligentes y robots. Gracias a la baja consumición de energía, el sensor de radar de Acconeer es idealmente apto para varias aplicaciones de Internet-of-Things (”IoT”), requiriendo la detección de la presencia de objetos o bien la distancia de objetos sin acceso a cableado y cuando una larga vida de batería es importante. Operaciones de batería y baja consumición de energía constituyen a menudo las primeras preocupaciones de clientes y ciudadanos, así como la reducción al mínimo de los efectos medioambientales del sistema.

**B. Discusiones regulatorias y elaboración de normas**

Acconeer es activa en discusiones regulatorias y elaboración de normas en el mundo entero respecto a la banda 57-71 GHz y ha creado un base de datos de esquemas regulatorios actuales y propuestos para más de 127 países. Esta información ha sido recopilada en contacto directo con autoridades y organizaciones industriales y se encuentra en continua expansión.

Las revisiones de las CONDICIONES TÉCNICAS DE OPERACIÓN PARA EL USO DE LA BANDA DE FRECUENCIAS 57-64 GHz de IFT (“la regulation IFT”) deberían armonizarse con las normas a través del mundo para que los consumidores mexicanos no sean afectados por diferencias regulatorias regionales que pudiesen limitar su elección de productos disponibiles. La alineación de IFT con ETSI EN 305 550 lograría este objetivo.

Hasta la fecha, más de 66 países confían en las normas implementadas por la comisión Europea[3/] y estipuladas en el estándar armonizado de ETSI 305 550[4/] para la banda 57-64 GHz, el que está en vigor desde hace más de seis años. La información sobre las normas y del estándar armonizado publicado se presentan en la **Tabla 1**.

***Tabla 1*** *Regulación europea, parámetros del transmisor dentro de banda*

| **Parámetro** | **DECISIÓN DE EJECUCIÓN DE LA COMMISIÓN (EU) 2019/1345** | **Publicación actual del estándar armonizado ETSI 305 550 (2014-10)** |
|---|---|---|
| Rango de frecuencia de funcionamiento | f(Mínima) ≥ 57 GHz<br>f(Máxima) ≤ 64 GHz | f(Mínima) ≥ 57 GHz<br>f(Máxima) ≤ 64 GHz |
| Efecto medio | 20 dBm PERI | 20 dBm PERI |
| Efecto conducido medio del transmisor | 10 dBm | - |
| Efecto medio de densidad espectral | - | 13 dBm/MHz PERI |

La Federal Communications Commission's ("FCC") acaba de publicar una noticia de reglamentación propuesta[5] ("NPRM") y Acconeer respalda la propuesta de la FCC de alinear sus normas para el radar 60 GHz con el estándar europeo, ETSI EN 305 550. Para espaldar esto,

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[3/] Commission Implementing Decision (EU) 2019/1345 (Aug. 2, 2019).

[4/] ETSI EN 305 550-1 V1.2.1 (2014-10), https://www.etsi.org/deliver/etsi_en/305500_305599/30555001/01.02.01_60/en_30555001v010201p.pdf

[5/] *Véase FCC Seeks to Enable State-of-the-Art Radar Sensors in the 60 GHz Band*, Notice of Proposed Rulemaking, FCC-21-83 (rel. July 14, 2021) ("*60 GHz NPRM*" or "*NPRM*").

Acconeer ha presentado Comentarios[6] y Respuesta para comentarios[7] de esta NPRM y 28 empresas han ingresado escritos en el FCC ET Docket No. 21-264 presentando la intención de colocar productos en el mercado estadounidense utilizando la tecnología de radar pulsado de Acconeer. Una lista de estos escritos se incluye en el apendice A para demostrar el gran interés del mecado en el radar pulsado. La mayoría de estas empresas actúan en una escala global dirigiéndose al mercado mexicano también. Estos escritos explican que es de interés público de adoptar normas conformes al estándar europeo, dado que esto aseguraría que los consumidores tengan acceso a las mismas tecnologías en una manera oportuna y rentable.[8] BrainLit AB, por ejemplo, explica que ellos utilizan la tecnología de radar pulsado de Acconeer para diversas aplicaciones con relación a salud y seguridad como  desinfección de salas y lámparas que emiten luz saludable.[9] En relacción con esto, ITEM declara que están hacienda planes de comercializar dispositivos con tecnología de radar pulsado que se utilizarán para activación sin contacto, lo que reduciría la transmission de virus como COVID-19.[10] RelyQ está planeando utilizar el radar pulsado de Acconeer para "aplicaciones industriales que potencialmente mejoren las seguridad y eficiencia de operaciones en la industria ferroviaria (supervisando infraestructura de carril y de vagones de carga) y la Industria de Petroleo y Gas (supervisando niveles de tanque)."[11] NEXTY,

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6/ *Véase Comments of Acconeer AB FCC ET Docket No. 21-264* (September 20, 2021) ("*Acconeer comments*").
7/ *Véase Reply Comments of Acconeer AB FCC ET Docket No. 21-264* (October 18, 2021) ("*Acconeer reply comments*").
8/ *Véase* Letter from Bernard Emby, CEO, TrickleStar Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 21-264 (filed Oct. 15, 2021).
9/ Letter from Peter Andersson, COO, BrainLit AB, ET Docket No. 21-264 (filed Oct. 14, 2021).
10/ Carta de Martin W. Fuhrer, Director of Engineering, ITEM, Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 21-264 (archivada oct. 15, 2021).
11/ Carta de William LeFebvre, CEO, relyQ LLC, to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 21-264 ( archivada oct. 15, 2021).

parte de Toyota Tsusho Corporation, indica que planean la distribución del radar pulsado de Acconeer, y que respaldan la adopción de normas flexibles correspondiendo a normas europeas para "hacerlo más fácil y menos costoso para diseñadores de productos para introducir nuevos peoductos en el mercado."[12]

La tabla 2 abajo comprende una selección de diferentes casos de uso identificados donde Acconeer actualmente está prestando asistencia activa de manera que clientes desarrollen productos por el mundo entero. Más detalles sobre sus respectivos rasgos se presentan en el apendice B.

***Table 2** Selection of use cases addressed by SRDs in 60 GHz*

| ID | Caso de uso | Función |
|---|---|---|
| A | Detección de pasajero en vehículo | Detección de presencia |
| B | Alarma de centurón de seguridad y supresión de airbag | Detección de presencia |
| C | Alarma amtirrobo en vehículo | Detección de presencia |
| D | Control de acceso a vehículo | Control de gestos |
| E | Navegación autónoma de vehículo | Detección de obstáculo |
| F | Percepción de vehículo autónomo | Clasificación de objeto |
| G | Sistema de alarma de infraestructura | Detección de presencia |
| H | Ocupación de espacio de párking | Clasificación de objeto |

[12/] Carta de Kyoichi Yamamoto, NEXTY Electronics Corporation, to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 21-264 (archivada sept. 17, 2021). *Véase también*, Carta de Kei Miyamori, President, Restar Electronics Americas Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 21-264 (archivada oct. 15, 2021).

| | | |
|---|---|---|
| I | Gestión de inventarios | Medición de nivel |
| J | Control de distribución | Medición de de tasa de flujo |
| K | Deportes y juegos inteactivos | Medición de velocidad |
| L | Control  de aparato | Control de gestos |

## C. Vista tecnológica del sistema de radar de pulso

Acconeer estima que la armonización es la major medida de lograr paridad regulatoria y sencillez para todos los tipos de sistemas de radar FDS que operan en la banda – radar de pulso 57-71 GHz, radar FMCW, y radar dependiente del protocolo 802.11ad/, como se ilustra en **Figure 1**.

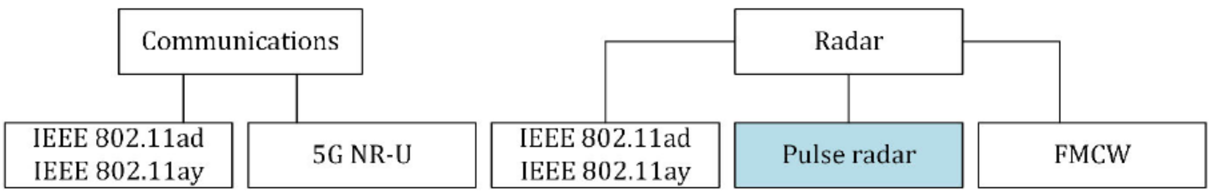


***Figure 1** Estándares y tecnologías en la banda 57-71 GHz*

Estos tipos de radar operan con diferentes estilos de transmission de manera que ciertas normas técnicas, como ciclo de trabajo, si se aplicaran de la misma manera, producirían resultados muy diferentes en términos de las capacidades operativas de los dispositivos. Por esta razón, la IFT debe considerer con cuidado el efteco de su propuesta actualización de la regulación y garantizar que las normas que finalmente adopten no lleguen a restricciones injustas para ciertas tecnologías y no para otras. Las normas de ETSI están elaboradas para evitar este efecto.

En el apendice C aquí se presentan los antecedentes del radar de puloso para demostrar la diferencia operacional entre FMCW y radar de pulso. Estas diferencias afectan el análisis  de tipo de radar y sistemas de 802.11ad/ay. Una coexistencia exitosa entre el radar de pulso y 802.11ad/ay puede garantizarse por las normas de ETSI, aún bajo condiciones extremas, lo que se discutirá más abajo.

La Figura 2 presenta una vista esquemática de un transmisión de radar de pulso. Pulsos se emiten en tirones, donde una secuencia de pulsos consecutivos se utilizan para muestrear un número de contenedores de rango.

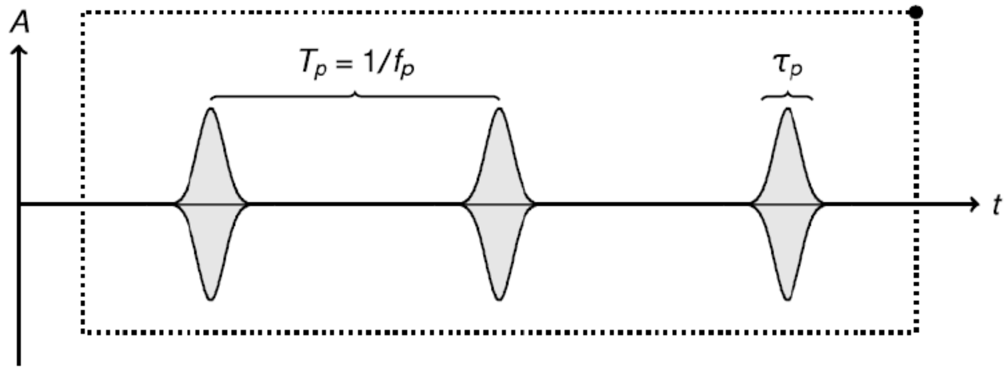


***Figure 2** Pulse*

*Definición del parámetro del sistema de radar de pulso*

La longitud de pulso, $\tau_p$, es la duración del pulso, y la frecuencia de repetición del pulso , $f_p$, es el tiempo inverso del tiempo entre el comienzo de dos pulsos consecutivos, $T_p$. Esto lo hace possible definir el ciclo de trabajo del radar de pulso como $\tau_p * f_p$. La Tabla 2 expone el típico rango de valores para los parámetros definidos que son necesarios para satisfacer los requisitos para los usos discutidos arriba. Estos valores sólo se proporcionan para describir un sistema de radar pulsado y deben ser construidos como parámetros sugeridos para nuevas normas.

***Tabla 3** Parámetro, símbolo y rango del valor típico de un radar de pulso*

| Parámetro | Símbolo | Valor típico |
|---|---|---|
| Longitud de pulso | $\tau_p$ | 0.35-6 ns |
| Frecuencuia de repetición de pulso | $f_p$ | 5-80 MHz |

Una ilustration de la densidad espectral de potencia de una señal de radar de pulso en la Figura 2 se enseña en la Figure 3.

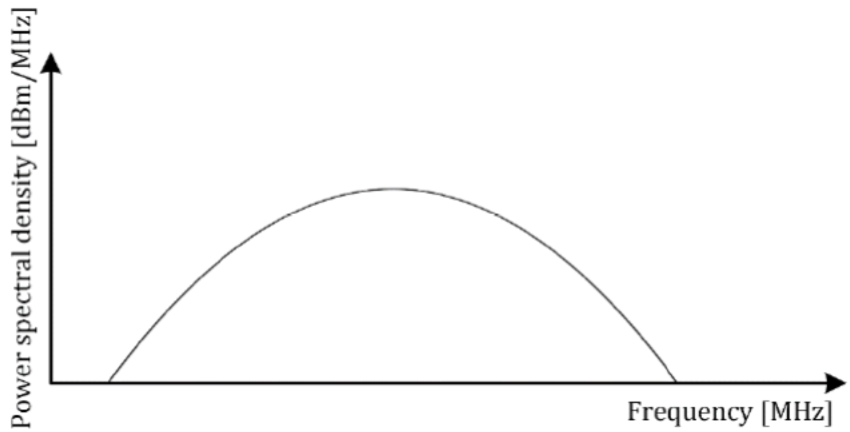

***Figure 3** Densidad spectral de la transmisión de pulso*

## DISCUSIÓN

Acconeer respalda los esfuerzos de IFT aquí para expandir la flexibilidad operativa de la banda de 60 GHz. En el proceder de FCC sobre el 60GHz NPRM, casi todas las partes afectadas se pusieron de acuerdo con la propuesta de FCC de adoptar normas consistentes con las regulaciones europeas, lo cual proporcionaría la flexibilidad, neutralidad y rápida entrada en el mercado buscada por los proponentes del radar. Acconeer considera que el Anteproyecto de Acuerdo es estrechamente definido basado en una exención de FCC concedida varios años atrás, habiendo sido negociada con el propósito de comercializar un tipo paarticular de dispositivo utilizando el radar FMCW. Mientras FCC entonces aplicó la misma condición para propósitos de conceder exenciones limitadas (ante todo para operaciones de FMCW dentro de vehículos) , FCC también reconoce que aquellas exenciones no eran "el alivio de base amplia" contemplado en esto, y que otras partes afectadas exigen tiempos de transmisión más largos.[13/]

La última meta en esto consiste en crear un ambiente suficientemente coexistente entre varios tipos diferentes de usuarios sin licencia. Está bien establecido en la regulación de IFT que usuarios que operan en esta banda de frecuencias no deben reclamar protección contra

13/ *Véase NPRM* ¶¶ 14, 31.

interferencias perjudiciales causadas por dispoitivos de sistema, equipo o estaciones de usuarios que tienen título habilitador de utilizar el espectro radioeléctrico, lo que significa que ningún otro usuario sin licencia operando en la banda 60 GHz podrá esparar operar en un entorno tranquilo o de interferencia limitada.[14/] El punto de partida en el desarrollo de normas debe implicar que todos los usuarios tendrán que diseñar sus equipos robustamente para operar alrededor de otras posibles fuentes de interferencia. La próxima consideracón debe ser la probabilidad de que cada usuario sin licencia opere hasta cierto grado de suficiencia.

La otra sugerencia del Anteproyecto de Acuerdo impone un período de tiempo de inactividad del radar, en que el radar necesita "parar de transmitir durante un tiempo continuo de por lo menos 26.4 milisecundos en cualquier interval de 33 milisecundos, o en su caso, tienen que parar de transmitir durante un tiempo continuo de por lo menos 2 milisecundos entre dos pulsos de transmission sucesivos"[15/]. Este período con radar eliminado tendría un impacto severo en un sistema de radar de pulso, así que IFT tendrá que rechazar esta propuesta completamente. La idea del radar eliminado proviene de una preocupación de que las tecnologías 802.11ad/ay serían capaces de operar virtualmente libres de interferencias en toda la banda, y esto se hizo sin tener en cuenta el efecto en el radar de pulso. La propuesta no considera que los sistemas de radar de pulso transmiten pulsos breves de baja potencia espectra media, resultando en una baja probabilidad de activación del mecanismo LBT del 802.11.ad/ay. En los apendices D, E, and F, Acconeer demuestra que el breve $\tau_p$, en el orden de una longitude de símbolo de 802.11ad/ay, de radar de pulso da un impacto mínimo impacto en el rendimiento del 802.11ad/ay. Esto transforma el tiempo con radar eliminado en un parámetro inadecuado para acceder a

14/ *Véase* sección 2.3.2 de Anteproyecto de Acuerdo.

15/ *Véase* sección 2.1.5 de Anteproyecto de Acuerdo.

802.11ad/ay y coexistencia de radar pulsado, así que Acconeer propone que el Anteproyecto de Acuerdo debe ser actualizado en un nuevo párrafo 2.1.6, inserteado entre los actuales 2.1.5 and 2.1.6, diciendo:

> "Sensores de perturbación de campo operando dentro de 57-64 GHz y empleando tecnología de radar pulsado han de operar con un promedio máximo de PERI de 13 dBm evaluado dentro de una ventana de tiempo de 0.3 µs, con un ciclo de trabajo máximo de 10% evaluado en una ventana de tiempo de 0.3 µs, y con una duración de pulso máxima de <6 ns"

Estudios de coexistencia para el 802.11ad/ay y el radar de pulso están previstos en appendices E and F. Simulaciones y mediaciones demuestran que una coexistencia exitosa es posible entre dispositivos de comunicación 802.11ad/ay y sistemas de radar de pulso. En general, el riesgo potencial de interferencia entre el el radar de pulso y tecnologías 802.11ad/ay technologies es bajo por las razones siguientes:

- Transmisiones de pulso breves permiten una codificación de corrección de errores del 802 .11ad/ay incluso funcionando bajo condiciones extremas e improbables en cuanto a la relación senal/interferencia ("SIR");
- La baja densidad espectral de potencia media del radar de pulso, con un bajo riesgo de desencadenar el mecanismo LBT del 802.11.ad/ay; y
  El bajo PERI medio comparado con niveles permitidos para los dispositivos de comunicación bajo Sección 15.255.

**CONCLUSION**

La actualización propuesta de la regulación de IFT socavaría una meta de neutralidad tecnológica, dado que no considera la tecnología de radar pulsado. Si la alineación con el estándar ETSI no se considera como una opción viable, es necesario hacer una adición a la IFT norma para asegurar que la tecnología de radar pulsado esté incluida. Una propuesta para tal adición al Anteproyecto de Acuerdo ha sido presentada en esta carta.

Respetuosamente,
ACCONEER AB

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25 de marzo de 2022

## APPENDIX A LIST OF ACCONEER CUSTOMER LETTERS

List of letters filed in the FCC ET Docket No. 21-264 proceeding indicating intent to put into the market products that use Acconeer pulse radar technology in the 60 GHz band.

| |
|---|
| Vtech Telecommunications Ltd. |
| NEXTY Electronics Corporation |
| ALPS ALPINE CO., LTD |
| relyQ LLC |
| Banner Engineering Corporation |
| Hosiden Corporation |
| GROOVE X Inc. |
| Tekelek Europe Ltd |
| TrickleStar Inc. |
| Brainlit AB |
| Restar Electronics Americas Inc. |
| Codico GmbH |
| DIGI-KEY ELECTRONICS |
| Packwise GmbH |
| eleven-x Inc |
| Sleepiz AG |
| Imagimob AB |
| OSM Group AB |
| ITEM Ltd. |
| Indesmatech ApS |
| Force Five Inc. |

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|---|
| Axis Communications AB |
| Zektur AB |
| TecAHEAD lncorporated |
| Julymonster Inc. |
| Väderstad AB |
| MicroSummit K.K. |
| Spoptech Inc. |

## APPENDIX B DEMAND FOR SHORT RANGE PULSED RADAR

During recent years, demand for new products operating in the 57-64 GHz band has grown tremendously. Acconeer supports removal of use case limitations from the rules so that consumers may have access to new technologies. **Table 4** lists a selection of different identified use cases where Acconeer today is actively helping customers develop end products. The subsequent sections provide more details about their respective features.

***Table 4*** *Selection of use cases addressed by SRDs in 60 GHz*

| **ID** | **Use case** | **Feature** |
|---|---|---|
| A | Vehicle passenger detection | Presence detection |
| B | Vehicle seat belt alarm and airbag suppression | Presence detection |
| C | Vehicle intruder alarm | Presence detection |
| D | Vehicle access control | Gesture control |
| E | Autonomous vehicle navigation | Obstacle detection |
| F | Autonomous vehicle perception | Object classification |
| G | Infrastructure alarm system | Presence detection |
| H | Parking space occupancy | Object classification |
| I | Inventory management | Level measurement |
| J | Dispense control | Flow rate measurement |
| K | Interactive sports and gaming | Speed measurement |
| L | Device control | Gesture control |

### 1. Presence Detection

Radar sensors can be used for motion sensing in Smart Home devices (*e.g.*, thermostats, smoke detectors, smart speakers, etc.), Smart Lightning systems, industrial automation, security systems including IP cameras, automated door openers, and screen based devices (*e.g.*, TV, notebook, tablet etc.) where low power consumption is important. Delivering accurate detection at low power consumption is one of the key benefits of pulsed radar.

The distance resolution of the radar is an important property used to determine the presence of multiple persons within the radar's field-of-view. A bandwidth of 500 MHz, as is allowed today for fixed installations with higher output power, limits the distance resolution and therefore hinders the ability to distinguish between different people present (*e.g.*, an infant vs. an adult). Limited available bandwidth also will increase a system's false positive rate. The power levels allowed today in the IFT regulation for the 57-64 GHz band do not allow for the marketing of an acceptable radar system that could provide accurate detection.

Automotive passenger detection, intruder alarm, and seat belt reminders are several important use case that require the accurate detection of human presence. Over the past twenty years, almost 900 children have died due to pediatric vehicular heatstroke in the United States alone. All of these deaths could have been prevented with technology such as Acconeer's radar system which, when operating in 60 GHz, can detect the presence of a child left in a vehicle. Millimeter wave ("mmWave") radar systems have advantages over other types of sensing systems, including camera-based systems or in-seat occupant detection systems. Unlike cameras, mmWave radar provides depth perception and can "see" through soft materials, such as a blanket covering a child in a child restraint. Unlike in-seat sensors, mmWave systems can differentiate between a child and an object left on the seat, reducing the likelihood of false alarms. In addition, mmWave radar can detect micro-movements like breathing patterns and heart rates, neither of which can be accurately captured by cameras or in-seat sensors alone.

Moreover, because passenger detection systems are active when a vehicle is stationary, it is critical that such systems engage in low power consumption to protect the vehicle's battery supply. Delivering accurate detection at low power consumption is one of the key merits of pulse radar technology.

Enhanced and persistent seatbelt reminders also can save lives. Pulse radar technology can detect breathing patterns and heart rates in a manner that permits discrimination between people and inanimate objects. From a safety perspective, when the sensor is used for seatbelt reminder function, it can more accurately detect the presence of a human in a seat than current pressure sensor technology. The same sensor also can be used to control a vehicle's passenger airbag suppression system, which is required to prevent injury to children in the event of an accident.

Pulse radar sensors also can enhance theft prevention systems by detecting a broken window or vehicle intrusion. While other sensors may be used for this purpose, mmWave radar is more efficient. For example, a camera-based sensor operates by taking multiple frames and comparing them, whereas radar takes a single scan and more accurately and efficiently acquires the same information. Thus, mmWave radar can increase the robustness of vehicle security systems. Furthermore, pulse radar in particular can significantly reduce the power consumption of an intruder alarm, prolonging the vehicle battery life. As already noted, low power consumption of systems within a vehicle while the vehicle is stationary is critical to the performance of a vehicle battery, and delivering accurate detection at low power consumption is one of the key merits of pulse radar technology.

### 2. Gesture Control

The desire for touchless intuitive interfaces to control devices is growing due to the COVID-19 pandemic, but also due to the desire to have a better way of interacting with devices that cannot have a touchscreen due to environment, size, or cost reasons. Examples of such uses include the activation of pedestrian crossing alerts, the control of in-ear headphones, and gesture-based vehicle entry/exit system – all of which require low power consumption enabled by pulse radar.

Gesture control for vehicle access promotes the public safety by allowing quick access to a vehicle in high-crime areas where it may be unsafe to loiter. Pulse radar can recognize a foot movement, for example, to open a car trunk or when opening or closing a sliding door when the vehicle is stationary. While other sensors may also be used for this purpose (such as capacitive systems), pulse radar can perform the function more robustly because of the millimeter accuracy provided by 60 GHz pulse radar, allowing for precise recognition of multiple gestures and the discrimination of false movements, while consuming small amounts of power. As noted, this low power consumption characteristic will greatly aid in prolonging a vehicle's battery life while parked. The gesture control detection system is only active when the vehicle is stationary, when low power consumption is critical. Again, delivering accurate detection at low power consumption is an important merit of pulse radar technology.

Another major benefit of pulse radar in the 57-64 GHz band is that the high bandwidth allows for the use of machine learning to identify gestures. This enables an accurate, low power non-intrusive way of controlling devices.

### 3. Obstacle Detection

The navigation systems used today by domestic robots such as vacuum cleaner robots, toy robots, or social robots rely on camera, infrared or ultrasonic based sensors. Pulse radar can accurately determine the location of transparent, soft, and dark materials, which can be a challenge with other technologies that may be sensitive to ambient lighting and sound conditions as well as dusty environments. In addition, radar does not have a lens or open aperture, which may become clogged and dirty, thereby losing the ability to perform. These factors – combined with the need for accurate detection of objects to avoid harm to humans or machines and the need for low power consumption for battery-powered devices – make pulse radar technology more suitable for use in these products requiring obstacle detection.

### 4. Object Classification

As discussed previously, the high bandwidth of pulse radar in the 57-64 GHz band enables the use of machine learning to solve complex use cases. For example, machine learning can perform object and material classification, allowing for cleaning and lawn mower robots to detect the surface on which they are operating. This permits cleaning robots to optimize their settings based on the surface and for lawn mower robots to stay within the lawn by detecting when they are entering a non-grassy surface.

Another use case for object classification is traffic and parking monitoring for Smart Cities. Parking space occupancy sensors can identify if a parking spot is vacant and reports this to a municipal Internet of Things (“IoT”) network. Use of such systems helps to limit traffic and pollution in major cities by minimizing time spent looking for a parking space. A parking sensor that relies on pulse radar for detection can operate in ambient lighting and various sound conditions and in dirty environments. In addition, these systems need to be able to run on battery for several years and need to be able to discriminate cars from other objects (*e.g.*, grocery carts) to avoid false detections. The pulse radar technology addresses these issues, delivering accurate detection at low power consumption.

High bandwidth is also needed for this use case, as the signal from a car is exposed to fading, *i.e.*, multiple reflections from the car arriving at the receiving antenna. These reflections can interfere constructively or destructively depending on their relative distances, meaning that in some cases the reflections from the car can interfere destructively with other reflections and the received signal will be reduced or disappear. The lower the bandwidth used, the higher the probability that this fading will occur. With a high bandwidth operation, the multi-path fading will be reduced. Hence, a bandwidth of 500 MHz, as is allowed today for fixed installations with higher output power, limits the distance resolution, reducing the ability of radar to perform object classification.

### 5. Level Measurement

Some industries, such as the process industry, agriculture, the petroleum industry, wastewater recycling, etc., need to determine the levels of liquids and solids in tanks for inventory and overflow protection. For these purposes, non-contact solutions are preferred, especially those which can be mounted outside the tank to measure through the container. In many cases, these devices are mounted without access to electrical installation and hence require radar systems with low power consumption.

Measuring levels within objects such as tanks creates similar concerns as a parked car that creates fading, *i.e.*, there can be multiple reflections from not only the surface of the liquid but also from the sides of the tank, the corners between the surface and tank walls, etc. These reflections, again, interfere constructively or destructively depending on their relative distances, meaning that in some cases the reflections from the surface can interfere destructively with other reflections and the received signal will be reduced or disappear. The lower the allowable bandwidth for measurements, the higher the probability that this fading will occur. With a high bandwidth, multi-path fading will be reduced. This is especially true in harsh environments, such as in distance monitoring in outdoor environments for agricultural and railway operations.

### 6. Flow Rate Measurement

Other industries, such as agriculture, health care, and food manufacturing, require the measurement of the flow of items (*e.g.*, seeds, grains, pellets and other solids) through pipes to calibrate rates and to ensure that no blockage has occurred. Pulse radar operating in the 57-64 GHz band provides a robust solution for measuring these properties without having to install a flow meter inside of a pipe. This is especially useful for operations where there are high standards for hygiene and cleanliness. In addition, pulse radar provides a robust means of taking accurate measurements in harsh outdoor environments, such as for agricultural operations. Some of these applications require very low power consumption, as they are used in battery-powered products, making Acconeer's radar solution a sought-after choice

Additionally, radar-enabled flow rate measurements also require high bandwidth to enable accurate pulse radar using machine-learning solutions.

### 7. Speed Measurement

Finally, several markets need to measure an object's speed. Some examples of common use cases are driving ranges and baseball batting cases (i.e., swing measurements), interactive playground installations, and short-range traffic monitoring applications. There is a public interest for allowing for improved Smart City applications, as well as sports and gaming products that can measure object speed. Several of these devices are battery-powered and therefore require technology that employs low power consumption.

## APPENDIX C PULSED RADAR TECHNOLOGICAL OVERVIEW

Acconeer believes that harmonization is the best means to achieve regulatory parity and simplicity for all types of FDS radar systems that operate in the 57-71 GHz band – pulse radar, FMCW radar, and radar relying on 802.11ad/ay protocol, as illustrated in **Figure 4**.

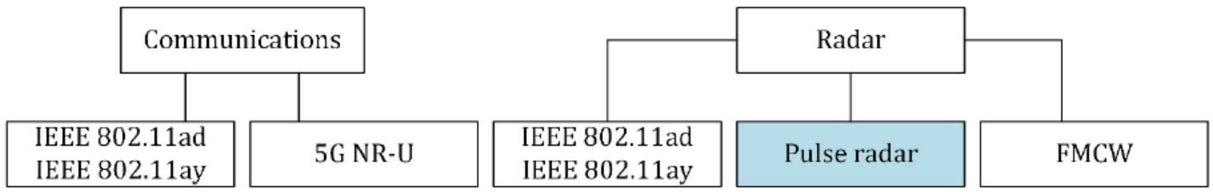


***Figure 4** Standards and technologies in the 57-71 GHz band*

These radars operate with different styles of transmissions so that certain technical rules, such as duty cycle, if applied in the same manner would produce vastly different results in terms of the operational abilities of the devices. For this reason, the IFT must carefully consider the effect of its proposed rules and ensure that the rules that it ultimately adopts do not result unfairly in operating constraints for some technologies but not others. The ETSI standards are crafted to avoid this effect.

Acconeer here provides a background on pulse radar to demonstrate the operational difference between FMCW and pulse radar. These differences affect the analysis of co-existence between each type of radar and 802.11ad/ay systems. Successful co-existence between pulse radar and 802.11ad/ay can be ensured by the ETSI standards, even under extreme conditions, as discussed further below.

**Figure 5** shows a schematic view of a pulse radar transmission. Pulses emit in sweeps, where a sequence of consecutive pulses is used to sample a number of range bins.

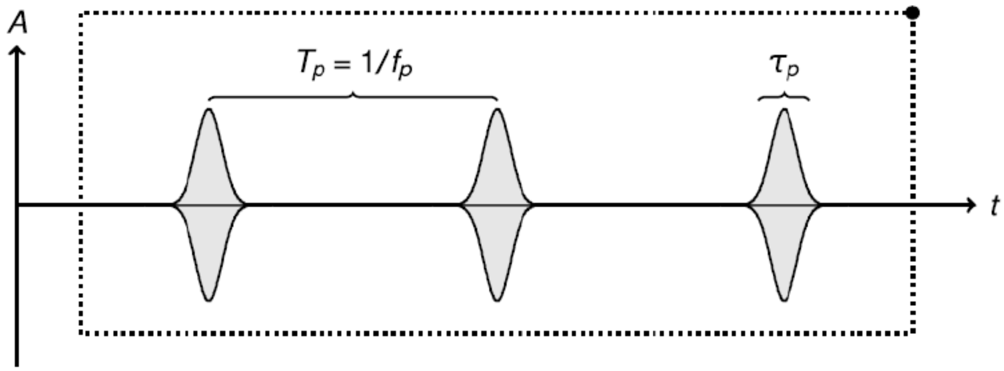


***Figure 5** Pulse radar system parameter definition*

The pulse length, $\tau_p$, is the duration of the pulse, and the pulse repetition frequency, $f_p$, is the inverse of the time between start of two consecutive pulses, $T_p$. This makes it possible to define the duty cycle of pulse radar as $\tau_p$*$f_p$. **Table 5** sets out the typical range of values for the defined parameters that are necessary to satisfy the requirements for the uses discussed above. These values are provided only to describe a pulse radar system and should not be construed as suggested parameters for new rules.

***Table 5** Parameter, symbol and range of typical value for pulse radar*

| Parameter | Symbol | Typical value |
|---|---|---|
| Pulse length | $\tau_p$ | 0.35-6 ns |
| Pulse repetition frequency | $f_p$ | 5-80 MHz |

An illustration of the power spectral density of a pulse radar signal in **Figure 5** is shown in **Figure 6**.

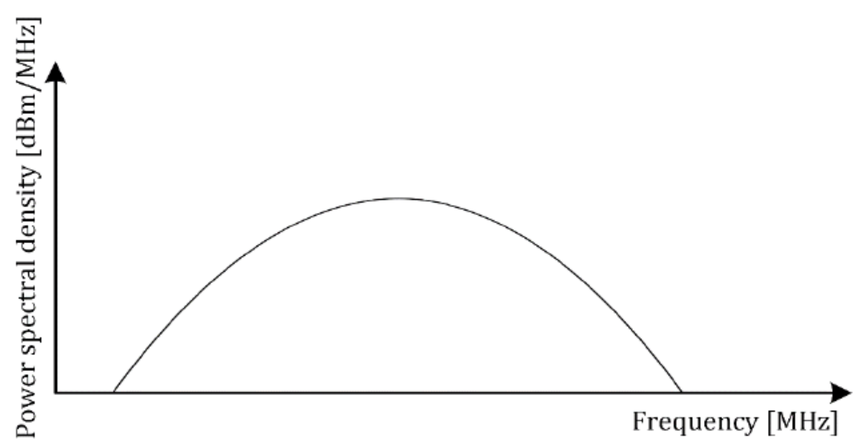

*Figure 6 Spectral density of pulse radar transmission*

Quantities related to power generated and emitted by pulse radar are:

- Peak EIRP in a pulse with duration $\tau_p$
- Mean EIRP during a time that is greater than $1/f_p$
- Maximum peak power spectral density emitted in band during a time that is greater than $1/f_p$
- Maximum mean power spectral density emitted in band during a time that is greater than $1/f_p$

Although pulse radar and FMCW radar are in some instances used to solve similar use cases, there are some key differences related to their spectrum footprint and the ability to co-exist with other systems:

- Duration of continuous transmission

Pulse radar transmits in short ns-long pulses that can co-exist with 802.11ad/ay 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"), as detailed below.[16/] As FMCW systems perform sweeps continuously during tens of μs to tens of ms, it is not possible for 802.11ad/ay systems to rely on error correction coding to maintain a high data rate during the slot occupied by the FMCW radar, given a high SIR.

- Mean EIRP

Pulse radar transmits short ns-long pulses at a duty cycle (defined as $\tau_p$*$f_p$) typically at or below 10%, which means that the mean EIRP is well below the peak EIRP. This is not the case for FMCW during transmission that would conform to the time scale of an 802.11ad/ay block

16/ *See* Appendix D of the Discussion section.

duration. This means that on average 802.11.ad/ay systems experience less interference from pulse radar than from FMCW during the time that the radar performs a sweep.

- Peak power spectral density ("PSD")

Pulse radar transmits short ns-long pulses, which are instantaneously spread across a wide bandwidth. This means that the maximum peak power spectral density as measured over an 802.11ad/ay channel is significantly lower for pulse radar than for FMCW radar. This decreases potential interference to 802.11ad/ay and means that the probability of the listen before talk ("LBT") mechanism of the 802.11ad/ay system is less likely to be triggered.

## APPENDIX D SUCCESFUL CO-EXISTENCE BETWEEN PULSE RADAR AND 802.11AD/AY

Simulations and measurements demonstrate that successful co-existence is possible between 802.11ad/ay communications devices and pulse radar systems. In general, the potential risk of interference from pulse radar to 802.11ad/ay technologies is low for the following reasons:

- Short pulse transmissions allow for error correction coding of 802.11ad/ay functioning, even under extreme and unlikely signal to interference ratio ("SIR") conditions;
- The low mean power spectral density of pulse radar, with a low risk of triggering the LBT mechanism of 802.11.ad/ay; and
- The low mean EIRP compared to levels allowed for communication devices under IFT regulation in the 57-64 GHz band.

There are numerous other reasons why 802.11ad/ay devices, including those designed for VR headsets requiring high throughput, can co-exist with pulse radar. These include the facts that 802.11ad/ay radios employ high beam forming gain, error correction coding, and short transmission distances. Indeed, only in extreme and unlikely conditions would there ever be perfect alignment between a pulse radar and an 802.11ad/ay receiver such that worse case scenarios would be likely. In that instance, the short bursts of interference from pulse radar would be mitigated by the 802.11ad inherent coding procedures. Of course, in worst-case conditions in any co-existence study, some decrease in throughput can be expected.

Given these factors, there exists an exceedingly low potential risk of interference. In addition, adoption of WiGig systems in this band have been low and no reports of interference issues have been reported,[17/] even in Europe where the ETSI 305 550 standard allows 20 dBm mean EIRP evaluated over at least one EUT cycle.

**Analytical Modelling and Measurement Study**

Acconeer has developed an analytical framework for evaluating the packet error rate ("PER") after decoding of an 802.11ad single carrier system that is under interference from a pulse radar. When evaluating the PER under such conditions, it is essential to consider that the interference affects only a certain fraction of the symbols in a WiGig packet. Hence, there will be a number of symbols unaffected by interference and some symbols affected by interference. The PER is then the result after joint decoding of the unaffected bits (typically having low bit error rates) and the affected bits (possibly having somewhat higher bit error rates due to interference).

Acconeer has attached a report,[18/] demonstrating that in the studied additive white Gaussian noise ("AWGN") cases the coding of the 802.11ad system makes it very robust to pulse radar interference, as only a very limited amount of the bits in any packet are interfered. Even with a very high interference level, the decoder is able to correct for the errors caused by interference. For this reason, 802.11ad devices would experience only a minor loss in performance even in the face of very high interference levels from pulse radars.

Calculations of the PER were performed for two cases with some simplifying assumptions. Case 1 considers short pulses and very high interference levels, while Case 2 considers long pulses and medium interference levels. In Case 1, the pulse is short so that only a single symbol is affected by a single pulse and the interference level is assumed so strong that

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17/ *See* Letter from Megan Anne Stull, Senior Counsel, Google LLC, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 21-48 (filed May 17, 2021) ("Google Ex Parte").

18/ *See* Appendix E ("Analytic calculation of the packet error rate of 802.11ad with pulse radar interference.")

the bit error rate is almost 50% when subjected to interference. In Case 2, the radar signals and the 802.11ad signals are equally strong but with a pulse length so that 6-7 symbols are affected per pulse. Acconeer's modeling shows that the 802.11ad system should be robust to pulse radar (and similar) interference, and with realistic radar parameters, the influence on the 802.11ad system should be limited.[19/]

In addition, Acconeer has attached interference measurement studies that were performed to demonstrate the findings of the analytical modeling studies.[20/] The study was done using commercially available 802.11ad devices and pulse radar. The conclusion is that no significant degradation of throughput to the 802.11ad system was observed even under extreme SIR values.

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19/ *See id*.

20/ *See* Appendix F ("Pulse radar to 802.11ad interference measurement study.").

## APPENDIX E – ANALYTIC CALCULATION OF THE PACKET ERROR RATE OF 802.11AD SUBJECT TO PULSE RADAR INTERFERENCE

In this appendix, we use an analytical framework for evaluating the packet error rate ("PER") of an 802.11ad single carrier system, after decoding, under interference from a pulse radar operating in the 60 GHz band. When evaluating the PER under such conditions, it is essential to consider that the interference affects only a limited fraction of the symbols in a packet. Hence, there will be a number of symbols unaffected by interference and a number of symbols affected by interference. The PER after decoding is the result of the bit error rates of the unaffected bits and the bit error rates of the affected bits. To make the translation from the two bit error rates to PER we use an approach used in the EU project MiWEBA from 2014,[21] where the full description of the framework can be found.

The link performance prediction is based on determining the function which maps multiple physical signal to interference and noise ("SINR") observations to a single "wide-band" metric which then can be converted to PER by means of a second mapping function (usually an AWGN reference). The physical layer abstraction method is based on the Mean Mutual Information per coded Bit ("MMIB") metric[22] and includes two steps:

- Calculation of MMIB metric for the given post-processing SINR values corresponded to each of the N symbols in the packet, *i.e.*, based on the signal to noise ratio ("SNR") for unaffected bits and SINR for affected bits; and
- MMIB to PER mapping.

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[21] MiWEBA, Millimetre-Wave Evolution for Backhaul and Access, WP4: Radio Resource Management for mm-wave Overlay HetNets, D4.1: System Level Simulator Specification, Dec 2014.

[22] K. Sayana, J. Zhauang and K. Stewart, "Short term link performance modeling for ML receivers with mutual information per bit metrics," Proc. IEEE GLOBECOM 2008, Nov. 2008.

Given this analytical framework, the performance of a single carrier 802.11ad system under interference from a pulse radar now can be evaluated. The calculations are done under the assumption that the interference can be seen as additive white Gaussian noise, which will give a good indication of the system performance.

The ratio of 802.11ad symbols impacted by interference is given by

$$X_{interference} = f_p/R_{ad} * \max(1, \tau_p * f_p),$$

where $R_{ad}$ is the symbol rate of 802.11ad, $\tau_p$ is the pulse length, and $f_p$ is the pulse repetition frequency of the pulse radar. These symbols will experience an SINR that is worse than the SNR that the rest of the symbols will experience. The ratio of symbols in a packet not impacted by interference therefore is given by

$$X_{non\text{-}interference} = 1 - X_{interference} = 1 - f_p/R_{ad} * \max(1, \tau_p * f_p).$$

The MMIB is now calculated as a sum of $X_{interference}$*MMIB with SINR=Z and $X_{non\text{-}interference}$*MMIB with SNR=Y, and then the corresponding PER is derived.

### Case 1, high interference, short pulses

In the following case study, we assume a signal to interference ratio ("SIR") of -30 dB, and vary the SNR and pulse repetition frequency. This scenario corresponds to a very high interference scenario so that the bit error rates for the symbols affected by interference is almost 50% and hence those symbols carry essentially no information.

**Figure 7** shows the analytical packet error rate for the 12 different modulation and coding schemes ("MCS") in 802.11ad for a pulse repetition frequency of 13 MHz and SIR=-30 dB. The red curve shows the PER with interference, whereas the blue curve shows the PER without interference for comparison. As seen in the figure, the influence of the interference is marginal on the packet error rate under those settings.

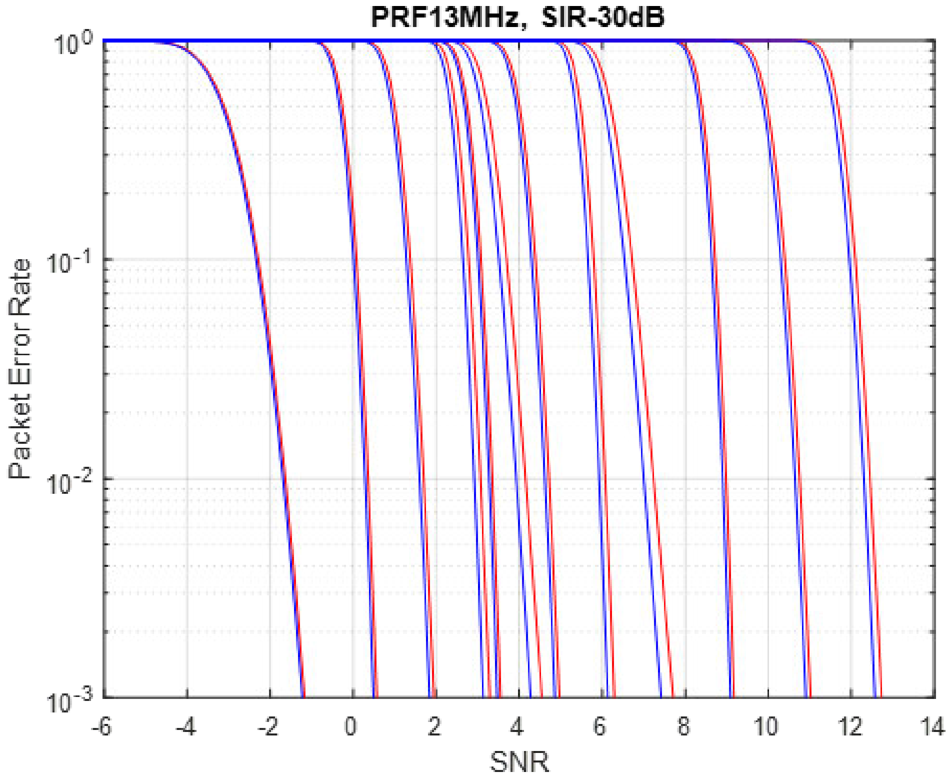



***Figure 7*** *Analytical packet error rate in an AWGN channel for the different MCS alternatives 1-12 for pulse repetition frequency 13 MHz and with a very high interference level, SIR=-30 dB. Red curve indicates the channel under interference, and the blue curve is without interference. Pulses are here 0.35 ns, hence shorter than the 802.11ad symbol time.*

### Case 2, medium interference, longer pulses

In the following analysis, we assume a signal to interference ratio ("SIR") of 0 dB and use longer pulses, $\tau_p$=3.6 ns. The longer pulses mean that on the average 6.3 of the 802.11ad symbols are affected by interference for every pulse, and with a pulse repetition frequency of 13 MHz, 4.7% of the 11ad symbols are affected by interference. Note that an SIR of 0 dB typically means that the radar is physically closer to the 802.11ad receiver than the 802.11ad transmitter due to the differences in antenna gains. If the radar is not aligned towards the 802.11ad receiver then the differences in distances can be rather large, with the radar even closer to the 802.11ad receiver.

**Figure 8** shows the packet error rate, and indicates that the influence of the pulse radar is only marginal to the performance of the 802.11ad system. For lower SNR values, there is essentially no influence as the SNR already is somewhat limited. For high SNRs, there is a slight performance loss and when being close to the boundary the 802.11ad system will back off to the closest but somewhat more robust MCS.

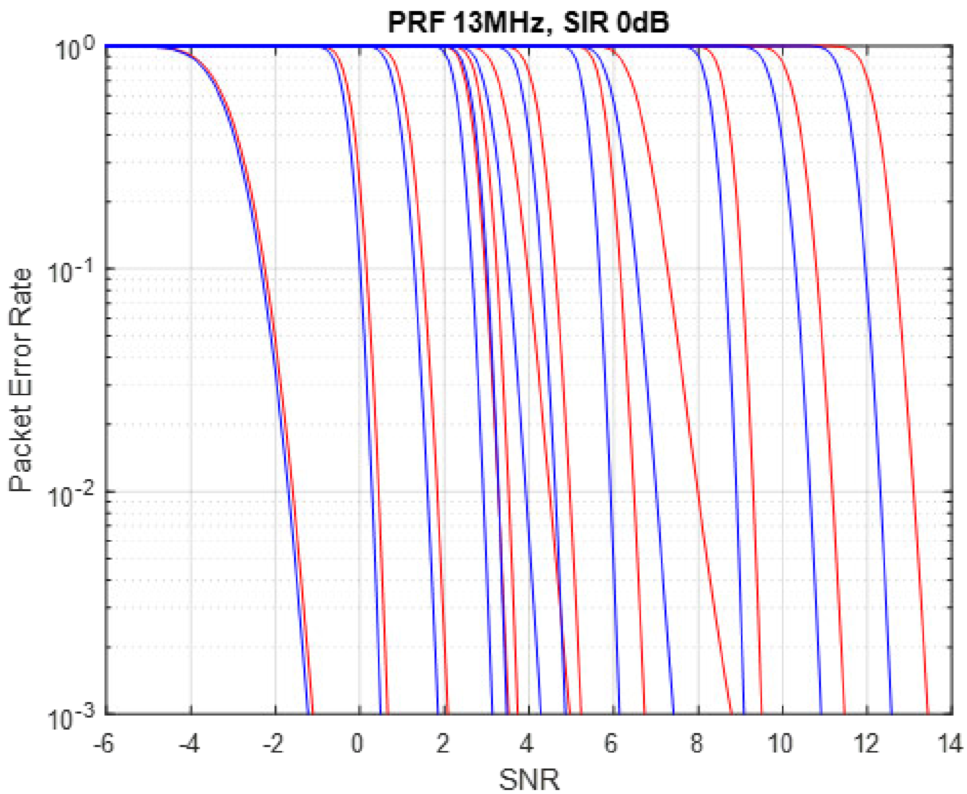



***Figure 8*** *Analytical packet error rate in an AWGN channel for the different MCS alternatives 1-12 for pulse repetition frequency 13 MHz and with a medium interference level, SIR=0 dB and longer pulses of 3.6 ns.*

## Conclusions

In the studied AWGN cases here, the coding makes the 802.11ad system very robust to pulse interference as only a part of the bits in a packet are interfered. Even with a very high interference level, the decoder is able to correct for the errors caused by interference. There is only a minor loss in performance even for very high interference levels.

Calculations of the PER have been shown for two cases with some simplifying assumptions, but the framework is general and can been used with various settings. Case 1 is for short pulses and very high interference levels, case 2 is for longer pulses and medium interference levels. In case 1, the pulse is short so that only a single symbol is affected by a single pulse, though the assumed interference level is so strong that the bit error rate would be almost 50% when subjected to interference. In case 2, the radar signals and the 802.11ad signals are equally strong but with a pulse length set so that 6-7 symbols are affected per pulse. Both of these evaluations demonstrate that an 802.11ad system should be robust to pulse-like interference and with realistic radar parameters the influence on the 802.11ad system should be limited.

***

I HEREBY CERTIFY THAT I AM THE TECHNICALLY QUALIFIED PERSON RESPONSIBLE FOR THE PREPARATION OF THIS ANALYSIS, AND THAT IT IS COMPLETE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

Fredrik Tufvesson, Ph.D
System Specialist
Acconeer AB
Västra Varvsgatan 19, 211 77 Malmö, Sweden
September 20, 2021

## APPENDIX F – PULSE RADAR TO 802.11AD INTERFERENCE MEASUREMENT STUDY

This measurement study investigates the interference from pulse radar to 802.11ad. Commercially available devices are used and the measurement setup is described in **Figure 9**.

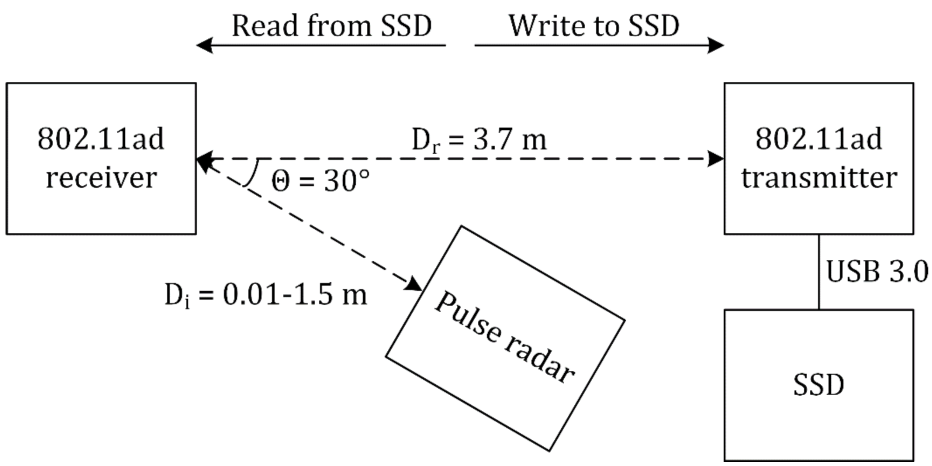



***Figure 9*** *Measurement setup*

The 802.11ad receiver is a Lenovo ThinkPad X270 PC with built-in WiGig Devices and the transmitter is a ThinkPad WiGig Docking station. The technical parameters of the 802.11ad equipment used is provided in **Table 6** and the technical parameters of the pulse radar equipment used is provided in **Table 7**.

***Table 6*** *Technical parameters of 802.11ad equipment used in interference measurement study*

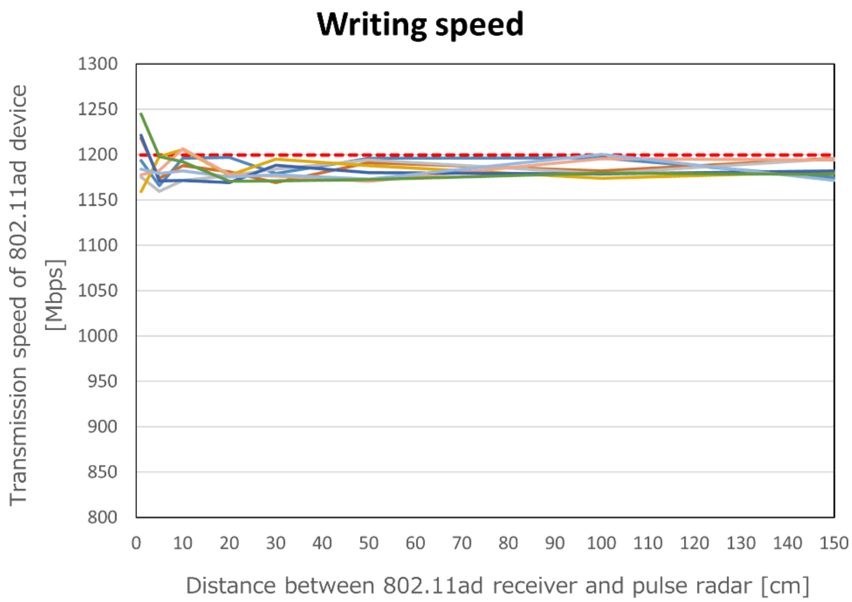
| | |
|---|---|
| **Center frequency** | 60.48 GHz |
| **802.11ad channel** | CH2（59.40-61.56GHz） |
| **802.11ad transmitter EIRP** | 23 dBm （estimated from measurement） |
| **TX/RX CH Bandwidth** | 2.16 GHz |
| **Modulation** | SC-BPSK/QPSK/16QAM<br>(estimated from communication speed） |

*Table 7 Technical parameters of pulse radar used in interference measurement study*

| | |
|---|---|
| **Center frequency** | 60.5 GHz |
| **Pulse width** | 0.35, 0.8, 2.0, 3.6 ns |
| **Peak EIRP** | 17 dBm |
| **Calculated SIR at the 802.11ad receiver antenna according to setup in Figure 1, pulse radar at 0.05 m.** | -31 dB + alignment factor due to the directional characteristics of the 802.11ad receive antenna |

The result from the measurement study is shown in

**Figure 10**. No decrease in throughput is observed even when the pulse radar is as close as 5 cm to the 802.11ad receiver. When the pulse radar was placed 1 cm from the 802.11ad receiver, the reading speed decreased; however the writing speed was not impacted. The decreased reading speed is attributed to the fact that the pulse radar shielded the 802.11ad signal. If considering the effect of the SIR caused by the pulse radar signal, the necessary separation distance between the 802.11ad receiver and the pulse radar to ensure low interference is shown to be less than 5 cm based on the setup used in this study.



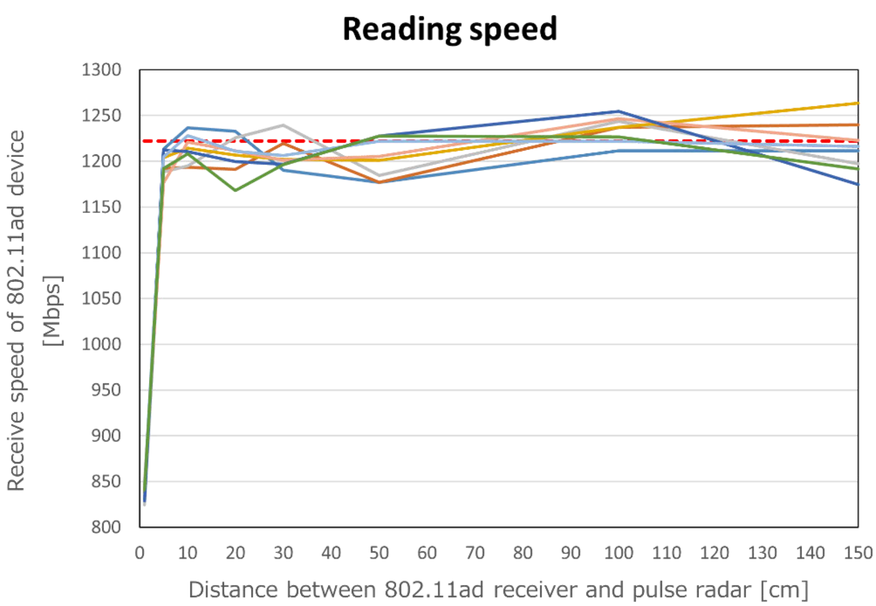




***Figure 10*** *Pulse radar to 802.11ad interference measurement study results. The calculated SIR at the 802.11ad receiver is -31 dB + alignment factor due to the directional characteristics of the 802.11ad receive antenna, when the pulse radar is positioned 5 cm from the 802.11ad receiver*

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I HEREBY CERTIFY THAT I AM THE TECHNICALLY QUALIFIED PERSON RESPONSIBLE FOR THE PREPARATION OF THIS ANALYSIS, AND THAT IT IS COMPLETE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

Mikael Egard, PhD
Chief Operating Officer
Acconeer AB
Västra Varvsgatan 19, 211 77 Malmö, Sweden
September 20, 2021

Before the
**Instituto Federal de Telecomunicaciones**
Insurgentes Sur #1143, Col. Christmas Eve,Benito Juárez Territorial Demarcation, Mexico City
03720

In the Matter of:
Consulta Pública sobre el "Anteproyecto de Acuerdo mediante el cual el Pleno del Instituto Federal de Telecomunicaciones actualiza las condiciones técnicas de operación para el uso de la banda de frecuencias 57-64 GHz, clasificada como espectro libre"

# COMMENTS OF ACCONEER AB

Mikael Rosenhed
Acconeer AB
Västra Varvsgatan 19
211 77 Malmö, Sweden

25th of March 2022

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## COMMENTS OF ACCONEER AB

Acconeer AB ("Acconeer") supports the Instituto Federal de Telecomunicaciones ("IFT") efforts here to expand the operational flexibility of the 57-64 GHz ("60 GHz") band.[1/] Acconeer has developed an innovative radar sensor that operates on 57-64 GHz, providing for a wide-range of use cases serving a number of industry sectors. Acconeer has many customers that seek to market Acconeer's innovative pulse radar solution for a number of functions worldwide. Moreover, because these customers design and sell their products on a global basis, it is vital to adopt rules in Mexico that would harmonize products with rules and standards already in use around the world. For these reasons, it would be in the public interest for the IFT to adopt new rules for 60 GHz Field Disturbance Sensors ("FDS", commonly referred to as "radar") consistent with the ETSI standard already in use throughout the world.[2/]

## BACKGROUND

### A. Introduction

Acconeer is a radar sensor development company located in Malmö, Sweden. Acconeer was formed in 2011 to develop innovative technologies based on research pioneered at Lund University and was listed on Nasdaq First North in 2017. Acconeer is a leader in developing small, power-efficient and cost-efficient radar systems that will enable a safer and more sustainable future.

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[1/] Anteproyecto de Acuerdo mediante el cual el Pleno del Instituto Federal de Telecomunicaciones actualiza las condiciones técnicas de operación para el uso de la banda de frecuencias 57-64 GHz, clasificada como espectro libre ("Anteproyecto de Acuerdo"), published by IFT on the 24th of February 2022

[2/] *See e.g.*, Electronic Comm. Committee, *ERC Recommendation 70-03*, 44-48 (2021), https://docdb.cept.org/download/25c41779-cd6e/Rec7003e.pdf.

Acconeer has developed an innovative 60 GHz pulsed coherent radar sensor which has the benefits of being produced in a compact form factor (*i.e.*, 5x5x0.8 mm) while consuming low amounts of power. Using the 60 GHz band allows Acconeer's radar sensor to detect extremely small variations in the local environment, such as the vital signs of a human being, while using small antennas that allow for the integration of the sensor into small form factors.

Acconeer's radar system can be used in a large variety of applications such as fixed systems that detect the presence of humans inside buildings and vehicles, and mobile, battery-operated devices such as cell phones, laptops, smart watches, and robots. Due to its low power consumption, Acconeer's radar sensor is ideally suited to various Internet-of-Things ("IoT") applications requiring detection of the presence of objects or the distance to objects where cabling is not feasible and long battery life is important. Battery operation and low power consumption are often the primary concerns of the customer and the public, including for the purpose of minimizing a system's environmental footprint.

**B. Regulatory discussions and rulemakings**

Acconeer is active in regulatory discussions and rulemaking proceedings worldwide regarding the 57-71 GHz band and has created a database of the current and proposed regulatory schemes for more than 127 countries. This information was gathered through direct contact with authorities and industry organizations and is continuously expanding. The IFT's revisions to CONDICIONES TÉCNICAS DE OPERACIÓN PARA EL USO DE LA BANDA DE FRECUENCIAS 57-64 GHz ("IFT regulation") should harmonize with rules across the globe so that Mexican consumers are not impacted by regional regulatory differences that could limit their product choice and availability. Aligning the IFT regulation with ETSI EN 305 550 would accomplish this goal.

To date, more than 66 countries rely on the rules implemented by the European Commission[3/] and stipulated in the ETSI 305 550[4/] harmonized standard for the 57-64 GHz band, which has been in effect for more than six years. Information on the rules and released harmonized standard is provided in **Table 1**.

***Table 1*** *European regulation, in-band transmitter parameters*

| **Parameter** | **COMMISSION IMPLEMENTING DECISION (EU) 2019/1345** | **Current released ETSI 305 550 harmonized standard (2014-10)** |
|---|---|---|
| Operating frequency range | f(Lowest) ≥ 57 GHz<br>f(Highest) ≤ 64 GHz | f(Lowest) ≥ 57 GHz<br>f(Highest) ≤ 64 GHz |
| Mean power | 20 dBm EIRP | 20 dBm EIRP |
| Mean transmitter conducted power | 10 dBm | - |
| Mean power spectral density | - | 13 dBm/MHz EIRP |

The Federal Communications Commission's ("FCC") has recently issued a notice of proposed rulemaking[5] ("NPRM") and Acconeer supports the FCC's proposal to align its rules for 60 GHz radar with the European standard, ETSI EN 305 550. To support this Acconeer has supplied Comments[6] and Reply to comments[7] to this NPRM and 28 companies have filed letters in FCC ET Docket No. 21-264 indicating the intent to place products into the U.S market using

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[3/] Commission Implementing Decision (EU) 2019/1345 (Aug. 2, 2019).

[4/] ETSI EN 305 550-1 V1.2.1 (2014-10), https://www.etsi.org/deliver/etsi_en/305500_305599/30555001/01.02.01_60/en_30555001v010201p.pdf

[5/] *See FCC Seeks to Enable State-of-the-Art Radar Sensors in the 60 GHz Band*, Notice of Proposed Rulemaking, FCC-21-83 (rel. July 14, 2021) ("*60 GHz NPRM*" or "*NPRM*").

[6/] *See Comments of Acconeer AB FCC ET Docket No. 21-264* (September 20, 2021) ("*Acconeer comments*").

[7/] *See Reply Comments of Acconeer AB FCC ET Docket No. 21-264* (October 18, 2021) ("*Acconeer reply comments*").

Acconeer's pulse radar technology. A list of these filings is included in appendix A, to demonstrate the large market interest in pulsed radar. Most of these companies act on a global scale and are addressing the Mexican market as well. These letters explain that it is in the public interest to adopt rules consistent with the European standard, as this will ensure that consumers receive access to the same innovative technologies in a timely, cost efficient manner.[8] BrainLit AB, for example, explains that it uses Acconeer's pulse radar technology for several health and safety related applications such as room disinfection and lights that emit healthy lighting.[9] Relatedly, ITEM states that is plans to market devices with pulse radar technology that that will be used for touchless activation, which would lessen the transmission of viruses such as COVID-19.[10] RelyQ plans to use Acconeer pulse radar for "industrial applications that potentially improve the safety and efficiency of operations in the Railroad Industry (monitoring rail infrastructure and freight cars) and the Oil & Gas Industry (monitoring tank levels)."[11] NEXTY, part of Toyota Tsusho Corporation, indicates that it plans to distribute Acconeer's pulse radar, and supports adoption of flexible rules in line with the European standards to "make it easier and less costly for product designers to bring new products to the market."[12]

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8/ *See* Letter from Bernard Emby, CEO, TrickleStar Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 21-264 (filed Oct. 15, 2021).
9/ Letter from Peter Andersson, COO, BrainLit AB, ET Docket No. 21-264 (filed Oct. 14, 2021).
10/ Letter from Martin W. Fuhrer, Director of Engineering, ITEM, Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 21-264 (filed Oct. 15, 2021).
11/ Letter from William LeFebvre, CEO, relyQ LLC, to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 21-264 (filed Oct. 15, 2021).
12/ Letter from Kyoichi Yamamoto, NEXTY Electronics Corporation, to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 21-264 (filed Sept. 17, 2021). *See also*, Letter from Kei Miyamori, President, Restar Electronics Americas Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 21-264 (filed Oct. 15, 2021).

Table 2 further lists a selection of different identified use cases where Acconeer today is actively helping customers develop end products worldwide. More details about their respective features are provided in appendix B.

***Table 2** Selection of use cases addressed by SRDs in 60 GHz*

| ID | Use case | Feature |
|---|---|---|
| A | Vehicle passenger detection | Presence detection |
| B | Vehicle seat belt alarm and airbag suppression | Presence detection |
| C | Vehicle intruder alarm | Presence detection |
| D | Vehicle access control | Gesture control |
| E | Autonomous vehicle navigation | Obstacle detection |
| F | Autonomous vehicle perception | Object classification |
| G | Infrastructure alarm system | Presence detection |
| H | Parking space occupancy | Object classification |
| I | Inventory management | Level measurement |
| J | Dispense control | Flow rate measurement |
| K | Interactive sports and gaming | Speed measurement |
| L | Device control | Gesture control |

### C. Pulse Radar System Technological Overview

Acconeer believes that harmonization is the best means to achieve regulatory parity and simplicity for all types of FDS radar systems that operate in the 57-71 GHz band – pulse radar, FMCW radar, and radar relying on 802.11ad/ay protocol, as illustrated in **Figure 1**.

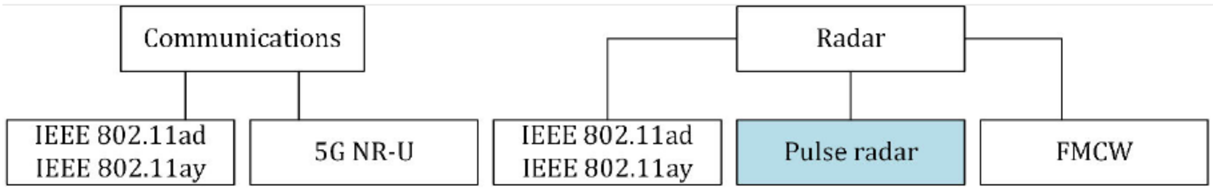


***Figure 1** Standards and technologies in the 57-71 GHz band*

These radars operate with different styles of transmissions so that certain technical rules, such as duty cycle, if applied in the same manner would produce vastly different results in terms of the operational abilities of the devices. For this reason, the IFT must carefully consider the effect of its proposed update of the regulation and ensure that the rules that it ultimately adopts do not result unfairly in operating constraints for some technologies but not others. The ETSI standards are crafted to avoid this effect.

In appendix C there is provided a background on pulsed radar to demonstrate the operational difference between FMCW and pulse radar. These differences affect the analysis of co-existence between each type of radar and 802.11ad/ay systems. Successful co-existence between pulse radar and 802.11ad/ay can be ensured by the ETSI standards, even under extreme conditions, as discussed further below.

Figure 2 shows a schematic view of a pulse radar transmission. Pulses emit in sweeps, where a sequence of consecutive pulses is used to sample a number of range bins.

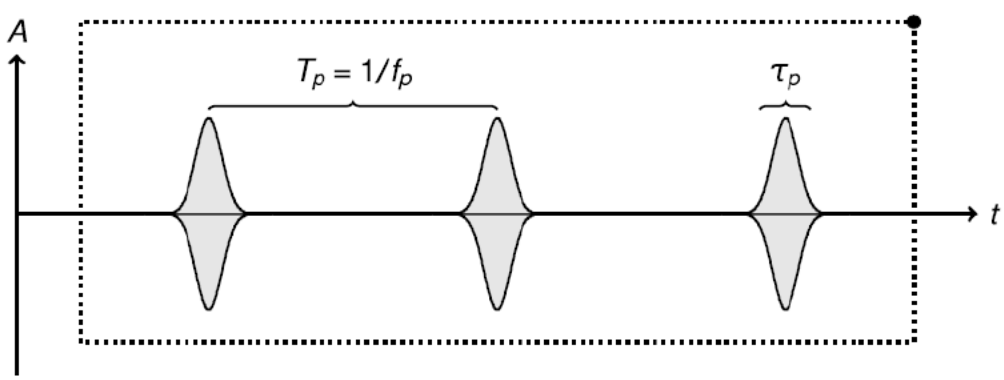


***Figure 2** Pulse radar system parameter definition*

The pulse length, $\tau_p$, is the duration of the pulse, and the pulse repetition frequency, $f_p$, is the inverse of the time between start of two consecutive pulses, $T_p$. This makes it possible to define the duty cycle of pulse radar as $\tau_p$*$f_p$. Table 2 sets out the typical range of values for the defined parameters that are necessary to satisfy the requirements for the uses discussed above. These values are provided only to describe a pulsed radar system and should not be construed as suggested parameters for new rules.

***Table 3** Parameter, symbol and range of typical value for pulse radar*

| Parameter | Symbol | Typical value |
|---|---|---|
| Pulse length | $\tau_p$ | 0.35-6 ns |
| Pulse repetition frequency | $f_p$ | 5-80 MHz |

An illustration of the power spectral density of a pulse radar signal in Figure 2 is shown in Figure 3.

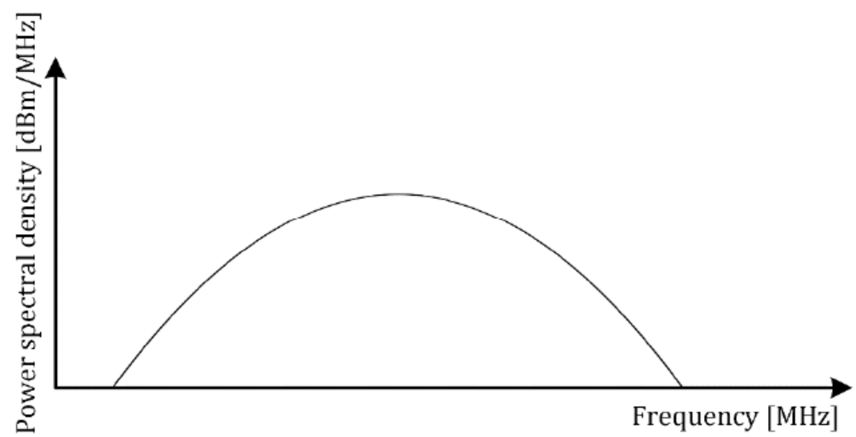


***Figure 3** Spectral density of pulse radar transmission*

## DISCUSSION

Acconeer supports the IFT efforts here to expand the operational flexibility of the 60 GHz band. In the FCC's proceeding on the 60 GHz NPRM, almost all parties agreed with the FCC proposal to adopt rules consistent with the European regulations. Doing so would provide the flexibility, technological neutrality, and quick market entry sought by radar proponents.

Acconeer views the Anteproyecto de Acuerdo to be narrowly defined based on an FCC waiver granted several years ago that was negotiated for the purpose of marketing one particular type of device using FMCW radar. While the FCC then applied this same condition for purposes of granting limited waivers (primarily for FMCW operations within vehicles), the FCC also recognizes that those waivers were not the "broad based relief" contemplated herein, and that other parties require longer transmission times.[13/]

The ultimate goal here is to create a sufficiently co-existent environment amongst several different types of unlicensed users. It is well established in the IFT regulation devices that operate in this band of frequencies may not claim protection against harmful interference caused by systems, devices, equipment or user stations that have an enabling title to make use of the radio spectrum, which means that no one unlicensed user operating in the 60 GHz band may expect to operate in a quiet or interference-limited environment.[14/] The starting point in the development of rules here must be that all users must design their equipment robustly to operate around other potential interfering sources. The next consideration must be the likelihood of all unlicensed users operating to some degree of sufficiency.

The suggestion made in Anteproyecto de Acuerdo imposes a "radar off" time period where the radar needs to "stop transmitting a continuous time of at least 26.4 milliseconds in any 33-millisecond interval, or where appropriate, they must stop transmitting a continuous time of at least 2 milliseconds between two successive transmit pulses"[15/]. This radar off period would have a severe impact on a pulse radar system, and the IFT must reject this proposal outright. The radar

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13/ *See NPRM* ¶¶ 14, 31.

14/ *See* section 2.3.2 of Anteproyecto de Acuerdo.

15/ *See* section 2.1.5 of Anteproyecto de Acuerdo.

off idea comes from a concern that 802.11ad/ay technologies should be able to operate virtually interference free across the entire band, and it was made without regard to the effect on pulse radar. The radar off proposal fails to consider that pulse radar systems transmit short pulses at low mean power spectral density, resulting in a low probability of triggering the LBT mechanism of 802.11.ad/ay. In appendix D, E, and F Acconeer demonstrates that the short $\tau_p$, on the order of an 802.11ad/ay symbol length, of pulse radar gives a minimal impact on 802.11ad/ay throughput. This makes radar off time an unsuitable parameter for addressing 802.11ad/ay and pulsed radar co-existence and Acconeer proposes that the Anteproyecto de Acuerdo should be updated to include a new paragraph 2.1.6, inserted between current 2.1.5 and 2.1.6, that reads:

> "2.1.6 Field disturbance sensors operating within 57-64 GHz and employing pulsed radar technology, shall operate with a maximum average EIRP of 13 dBm evaluated in 0.3 us time average window, with a maximum duty cycle of 10% evaluated in 0.3 us time average window, and with a maximum pulse duration <6 ns"

Co-existence studies for 802.11ad/ay and pulse radar is provided in appendix E and F. Simulations and measurements demonstrate that successful co-existence is possible between 802.11ad/ay communications devices and pulse radar systems. In general, the potential risk of interference from pulse radar to 802.11ad/ay technologies is low for the following reasons:

- Short pulse transmissions allow for error correction coding of 802.11ad/ay functioning, even under extreme and unlikely signal to interference ratio ("SIR") conditions;
- The low mean power spectral density of pulse radar, with a low risk of triggering the LBT mechanism of 802.11.ad/ay; and

  The low mean EIRP compared to levels allowed for communication devices under Section 15.255.

## CONCLUSION

The proposed update of the IFT regulation would undermine a goal of technological neutrality, as it does not consider pulsed radar technology. If the alignment to ETSI standard is not considered a viable option, then an addition needs to be made to the IFT regulation to ensure that pulsed radar technology is included. A proposal for such an addition to Anteproyecto de Acuerdo has been presented in this letter.

Respectfully submitted,
ACCONEER AB

[redacted]

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March 25, 2022

## APPENDIX A LIST OF ACCONEER CUSTOMER LETTERS

List of letters filed in the FCC ET Docket No. 21-264 proceeding indicating intent to put into the market products that use Acconeer pulse radar technology in the 60 GHz band.

| |
|---|
| Vtech Telecommunications Ltd. |
| NEXTY Electronics Corporation |
| ALPS ALPINE CO., LTD |
| relyQ LLC |
| Banner Engineering Corporation |
| Hosiden Corporation |
| GROOVE X Inc. |
| Tekelek Europe Ltd |
| TrickleStar Inc. |
| Brainlit AB |
| Restar Electronics Americas Inc. |
| Codico GmbH |
| DIGI-KEY ELECTRONICS |
| Packwise GmbH |
| eleven-x Inc |
| Sleepiz AG |
| Imagimob AB |
| OSM Group AB |
| ITEM Ltd. |
| Indesmatech ApS |

| |
|---|
| Force Five Inc. |
| Axis Communications AB |
| Zektur AB |
| TecAHEAD lncorporated |
| Julymonster Inc. |
| Väderstad AB |
| MicroSummit K.K. |
| Spoptech Inc. |

## APPENDIX B DEMAND FOR SHORT RANGE PULSED RADAR

During recent years, demand for new products operating in the 57-64 GHz band has grown tremendously. Acconeer supports removal of use case limitations from the rules so that consumers may have access to new technologies. **Table 4** lists a selection of different identified use cases where Acconeer today is actively helping customers develop end products. The subsequent sections provide more details about their respective features.

***Table 4*** *Selection of use cases addressed by SRDs in 60 GHz*

| ID | Use case | Feature |
|---|---|---|
| A | Vehicle passenger detection | Presence detection |
| B | Vehicle seat belt alarm and airbag suppression | Presence detection |
| C | Vehicle intruder alarm | Presence detection |
| D | Vehicle access control | Gesture control |
| E | Autonomous vehicle navigation | Obstacle detection |
| F | Autonomous vehicle perception | Object classification |
| G | Infrastructure alarm system | Presence detection |
| H | Parking space occupancy | Object classification |
| I | Inventory management | Level measurement |
| J | Dispense control | Flow rate measurement |
| K | Interactive sports and gaming | Speed measurement |
| L | Device control | Gesture control |

### 1. Presence Detection

Radar sensors can be used for motion sensing in Smart Home devices (*e.g.*, thermostats, smoke detectors, smart speakers, etc.), Smart Lightning systems, industrial automation, security systems including IP cameras, automated door openers, and screen based devices (*e.g.*, TV, notebook, tablet etc.) where low power consumption is important. Delivering accurate detection at low power consumption is one of the key benefits of pulsed radar.

The distance resolution of the radar is an important property used to determine the presence of multiple persons within the radar's field-of-view. A bandwidth of 500 MHz, as is allowed today for fixed installations with higher output power, limits the distance resolution and therefore hinders the ability to distinguish between different people present (*e.g.*, an infant vs. an adult). Limited available bandwidth also will increase a system's false positive rate. The power levels allowed today in the IFT regulation for the 57-64 GHz band do not allow for the marketing of an acceptable radar system that could provide accurate detection.

Automotive passenger detection, intruder alarm, and seat belt reminders are several important use case that require the accurate detection of human presence. Over the past twenty years, almost 900 children have died due to pediatric vehicular heatstroke in the United States alone. All of these deaths could have been prevented with technology such as Acconeer's radar system which, when operating in 60 GHz, can detect the presence of a child left in a vehicle. Millimeter wave ("mmWave") radar systems have advantages over other types of sensing systems, including camera-based systems or in-seat occupant detection systems. Unlike cameras, mmWave radar provides depth perception and can "see" through soft materials, such as a blanket covering a child in a child restraint. Unlike in-seat sensors, mmWave systems can differentiate between a child and an object left on the seat, reducing the likelihood of false alarms. In addition, mmWave radar can detect micro-movements like breathing patterns and heart rates, neither of which can be accurately captured by cameras or in-seat sensors alone.

Moreover, because passenger detection systems are active when a vehicle is stationary, it is critical that such systems engage in low power consumption to protect the vehicle's battery supply. Delivering accurate detection at low power consumption is one of the key merits of pulse radar technology.

Enhanced and persistent seatbelt reminders also can save lives. Pulse radar technology can detect breathing patterns and heart rates in a manner that permits discrimination between people and inanimate objects. From a safety perspective, when the sensor is used for seatbelt reminder function, it can more accurately detect the presence of a human in a seat than current pressure sensor technology. The same sensor also can be used to control a vehicle's passenger airbag suppression system, which is required to prevent injury to children in the event of an accident.

Pulse radar sensors also can enhance theft prevention systems by detecting a broken window or vehicle intrusion. While other sensors may be used for this purpose, mmWave radar is more efficient. For example, a camera-based sensor operates by taking multiple frames and comparing them, whereas radar takes a single scan and more accurately and efficiently acquires the same information. Thus, mmWave radar can increase the robustness of vehicle security systems. Furthermore, pulse radar in particular can significantly reduce the power consumption of an intruder alarm, prolonging the vehicle battery life. As already noted, low power consumption of systems within a vehicle while the vehicle is stationary is critical to the performance of a vehicle battery, and delivering accurate detection at low power consumption is one of the key merits of pulse radar technology.

### 2. Gesture Control

The desire for touchless intuitive interfaces to control devices is growing due to the COVID-19 pandemic, but also due to the desire to have a better way of interacting with devices that cannot have a touchscreen due to environment, size, or cost reasons. Examples of such uses include the activation of pedestrian crossing alerts, the control of in-ear headphones, and gesture-based vehicle entry/exit system – all of which require low power consumption enabled by pulse radar.

Gesture control for vehicle access promotes the public safety by allowing quick access to a vehicle in high-crime areas where it may be unsafe to loiter. Pulse radar can recognize a foot movement, for example, to open a car trunk or when opening or closing a sliding door when the vehicle is stationary. While other sensors may also be used for this purpose (such as capacitive systems), pulse radar can perform the function more robustly because of the millimeter accuracy provided by 60 GHz pulse radar, allowing for precise recognition of multiple gestures and the discrimination of false movements, while consuming small amounts of power. As noted, this low power consumption characteristic will greatly aid in prolonging a vehicle's battery life while parked. The gesture control detection system is only active when the vehicle is stationary, when low power consumption is critical. Again, delivering accurate detection at low power consumption is an important merit of pulse radar technology.

Another major benefit of pulse radar in the 57-64 GHz band is that the high bandwidth allows for the use of machine learning to identify gestures. This enables an accurate, low power non-intrusive way of controlling devices.

### 3. Obstacle Detection

The navigation systems used today by domestic robots such as vacuum cleaner robots, toy robots, or social robots rely on camera, infrared or ultrasonic based sensors. Pulse radar can accurately determine the location of transparent, soft, and dark materials, which can be a challenge with other technologies that may be sensitive to ambient lighting and sound conditions as well as dusty environments. In addition, radar does not have a lens or open aperture, which may become clogged and dirty, thereby losing the ability to perform. These factors – combined with the need for accurate detection of objects to avoid harm to humans or machines and the need for low power consumption for battery-powered devices – make pulse radar technology more suitable for use in these products requiring obstacle detection.

### 4. Object Classification

As discussed previously, the high bandwidth of pulse radar in the 57-64 GHz band enables the use of machine learning to solve complex use cases. For example, machine learning can perform object and material classification, allowing for cleaning and lawn mower robots to detect the surface on which they are operating. This permits cleaning robots to optimize their settings based on the surface and for lawn mower robots to stay within the lawn by detecting when they are entering a non-grassy surface.

Another use case for object classification is traffic and parking monitoring for Smart Cities. Parking space occupancy sensors can identify if a parking spot is vacant and reports this to a municipal Internet of Things ("IoT") network. Use of such systems helps to limit traffic and pollution in major cities by minimizing time spent looking for a parking space. A parking sensor that relies on pulse radar for detection can operate in ambient lighting and various sound conditions and in dirty environments. In addition, these systems need to be able to run on battery for several years and need to be able to discriminate cars from other objects (*e.g.*, grocery carts) to avoid false detections. The pulse radar technology addresses these issues, delivering accurate detection at low power consumption.

High bandwidth is also needed for this use case, as the signal from a car is exposed to fading, *i.e.*, multiple reflections from the car arriving at the receiving antenna. These reflections can interfere constructively or destructively depending on their relative distances, meaning that in some cases the reflections from the car can interfere destructively with other reflections and the received signal will be reduced or disappear. The lower the bandwidth used, the higher the probability that this fading will occur. With a high bandwidth operation, the multi-path fading will be reduced. Hence, a bandwidth of 500 MHz, as is allowed today for fixed installations with higher output power, limits the distance resolution, reducing the ability of radar to perform object classification.

### 5. Level Measurement

Some industries, such as the process industry, agriculture, the petroleum industry, wastewater recycling, etc., need to determine the levels of liquids and solids in tanks for inventory and overflow protection. For these purposes, non-contact solutions are preferred, especially those which can be mounted outside the tank to measure through the container. In many cases, these devices are mounted without access to electrical installation and hence require radar systems with low power consumption.

Measuring levels within objects such as tanks creates similar concerns as a parked car that creates fading, *i.e.*, there can be multiple reflections from not only the surface of the liquid but also from the sides of the tank, the corners between the surface and tank walls, etc. These reflections, again, interfere constructively or destructively depending on their relative distances, meaning that in some cases the reflections from the surface can interfere destructively with other reflections and the received signal will be reduced or disappear. The lower the allowable bandwidth for measurements, the higher the probability that this fading will occur. With a high bandwidth, multi-path fading will be reduced. This is especially true in harsh environments, such as in distance monitoring in outdoor environments for agricultural and railway operations.

**6. Flow Rate Measurement**

Other industries, such as agriculture, health care, and food manufacturing, require the measurement of the flow of items (*e.g.*, seeds, grains, pellets and other solids) through pipes to calibrate rates and to ensure that no blockage has occurred. Pulse radar operating in the 57-64 GHz band provides a robust solution for measuring these properties without having to install a flow meter inside of a pipe. This is especially useful for operations where there are high standards for hygiene and cleanliness. In addition, pulse radar provides a robust means of taking accurate measurements in harsh outdoor environments, such as for agricultural operations. Some of these applications require very low power consumption, as they are used in battery-powered products, making Acconeer's radar solution a sought-after choice

Additionally, radar-enabled flow rate measurements also require high bandwidth to enable accurate pulse radar using machine-learning solutions.

**7. Speed Measurement**

Finally, several markets need to measure an object's speed. Some examples of common use cases are driving ranges and baseball batting cases (i.e., swing measurements), interactive playground installations, and short-range traffic monitoring applications. There is a public interest for allowing for improved Smart City applications, as well as sports and gaming products that can measure object speed. Several of these devices are battery-powered and therefore require technology that employs low power consumption.

## APPENDIX C PULSED RADAR TECHNOLOGICAL OVERVIEW

Acconeer believes that harmonization is the best means to achieve regulatory parity and simplicity for all types of FDS radar systems that operate in the 57-71 GHz band – pulse radar, FMCW radar, and radar relying on 802.11ad/ay protocol, as illustrated in **Figure 4**.

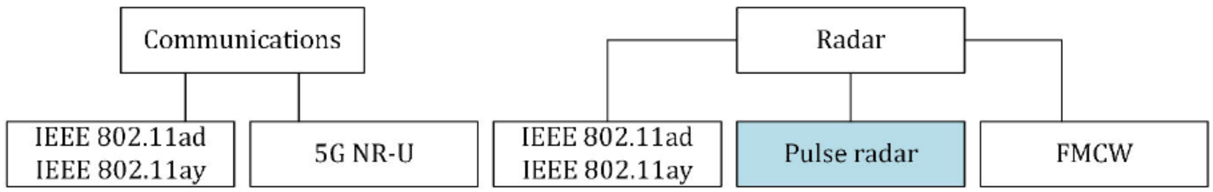


***Figure 4*** *Standards and technologies in the 57-71 GHz band*

These radars operate with different styles of transmissions so that certain technical rules, such as duty cycle, if applied in the same manner would produce vastly different results in terms of the operational abilities of the devices. For this reason, the IFT must carefully consider the effect of its proposed rules and ensure that the rules that it ultimately adopts do not result unfairly in operating constraints for some technologies but not others. The ETSI standards are crafted to avoid this effect.

Acconeer here provides a background on pulse radar to demonstrate the operational difference between FMCW and pulse radar. These differences affect the analysis of co-existence between each type of radar and 802.11ad/ay systems. Successful co-existence between pulse radar and 802.11ad/ay can be ensured by the ETSI standards, even under extreme conditions, as discussed further below.

**Figure 5** shows a schematic view of a pulse radar transmission. Pulses emit in sweeps, where a sequence of consecutive pulses is used to sample a number of range bins.

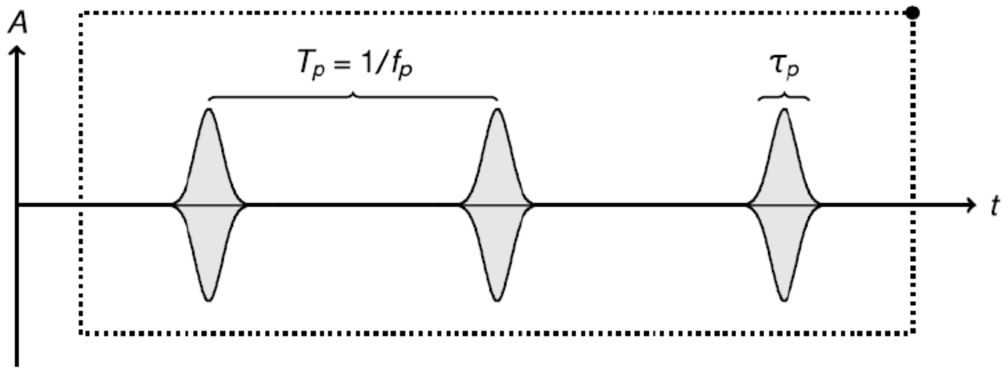


***Figure 5** Pulse radar system parameter definition*

The pulse length, $\tau_p$, is the duration of the pulse, and the pulse repetition frequency, $f_p$, is the inverse of the time between start of two consecutive pulses, $T_p$. This makes it possible to define the duty cycle of pulse radar as $\tau_p$*$f_p$. **Table 5** sets out the typical range of values for the defined parameters that are necessary to satisfy the requirements for the uses discussed above. These values are provided only to describe a pulse radar system and should not be construed as suggested parameters for new rules.

***Table 5** Parameter, symbol and range of typical value for pulse radar*

| Parameter | Symbol | Typical value |
|---|---|---|
| Pulse length | $\tau_p$ | 0.35-6 ns |
| Pulse repetition frequency | $f_p$ | 5-80 MHz |

An illustration of the power spectral density of a pulse radar signal in **Figure 5** is shown in **Figure 6**.

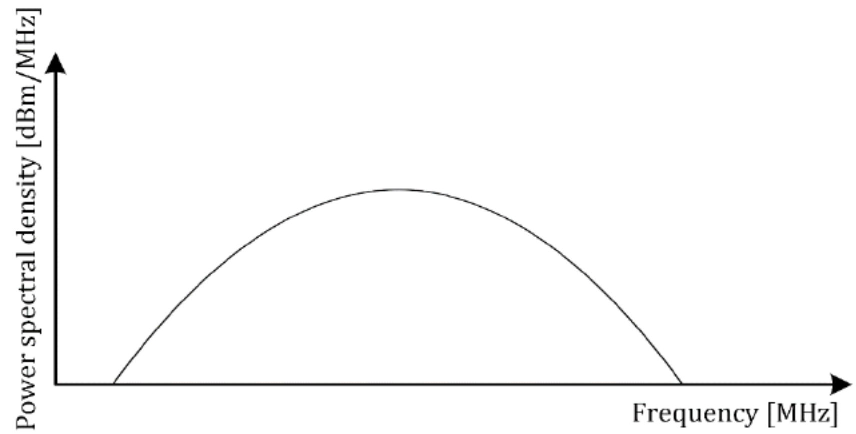

***Figure 6*** *Spectral density of pulse radar transmission*

Quantities related to power generated and emitted by pulse radar are:

- Peak EIRP in a pulse with duration $\tau_p$
- Mean EIRP during a time that is greater than $1/f_p$
- Maximum peak power spectral density emitted in band during a time that is greater than $1/f_p$
- Maximum mean power spectral density emitted in band during a time that is greater than $1/f_p$

Although pulse radar and FMCW radar are in some instances used to solve similar use cases, there are some key differences related to their spectrum footprint and the ability to co-exist with other systems:

- Duration of continuous transmission

Pulse radar transmits in short ns-long pulses that can co-exist with 802.11ad/ay 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"), as detailed below.[16/] As FMCW systems perform sweeps continuously during tens of µs to tens

16/ *See* Appendix D of the Discussion section.

of ms, it is not possible for 802.11ad/ay systems to rely on error correction coding to maintain a high data rate during the slot occupied by the FMCW radar, given a high SIR.

- Mean EIRP

Pulse radar transmits short ns-long pulses at a duty cycle (defined as $\tau_p*f_p$) typically at or below 10%, which means that the mean EIRP is well below the peak EIRP. This is not the case for FMCW during transmission that would conform to the time scale of an 802.11ad/ay block duration. This means that on average 802.11.ad/ay systems experience less interference from pulse radar than from FMCW during the time that the radar performs a sweep.

- Peak power spectral density ("PSD")

Pulse radar transmits short ns-long pulses, which are instantaneously spread across a wide bandwidth. This means that the maximum peak power spectral density as measured over an 802.11ad/ay channel is significantly lower for pulse radar than for FMCW radar. This decreases potential interference to 802.11ad/ay and means that the probability of the listen before talk ("LBT") mechanism of the 802.11ad/ay system is less likely to be triggered.

## APPENDIX D SUCCESFUL CO-EXISTENCE BETWEEN PULSE RADAR AND 802.11AD/AY

Simulations and measurements demonstrate that successful co-existence is possible between 802.11ad/ay communications devices and pulse radar systems. In general, the potential risk of interference from pulse radar to 802.11ad/ay technologies is low for the following reasons:

- Short pulse transmissions allow for error correction coding of 802.11ad/ay functioning, even under extreme and unlikely signal to interference ratio ("SIR") conditions;
- The low mean power spectral density of pulse radar, with a low risk of triggering the LBT mechanism of 802.11.ad/ay; and
- The low mean EIRP compared to levels allowed for communication devices under IFT regulation in the 57-64 GHz band.

There are numerous other reasons why 802.11ad/ay devices, including those designed for VR headsets requiring high throughput, can co-exist with pulse radar. These include the facts that 802.11ad/ay radios employ high beam forming gain, error correction coding, and short transmission distances. Indeed, only in extreme and unlikely conditions would there ever be perfect alignment between a pulse radar and an 802.11ad/ay receiver such that worse case scenarios would be likely. In that instance, the short bursts of interference from pulse radar would be mitigated by the 802.11ad inherent coding procedures. Of course, in worst-case conditions in any co-existence study, some decrease in throughput can be expected.

Given these factors, there exists an exceedingly low potential risk of interference. In addition, adoption of WiGig systems in this band have been low and no reports of interference issues have been reported,[17/] even in Europe where the ETSI 305 550 standard allows 20 dBm mean EIRP evaluated over at least one EUT cycle.

**Analytical Modelling and Measurement Study**

Acconeer has developed an analytical framework for evaluating the packet error rate ("PER") after decoding of an 802.11ad single carrier system that is under interference from a pulse radar. When evaluating the PER under such conditions, it is essential to consider that the interference affects only a certain fraction of the symbols in a WiGig packet. Hence, there will be a number of symbols unaffected by interference and some symbols affected by interference. The PER is then the result after joint decoding of the unaffected bits (typically having low bit error rates) and the affected bits (possibly having somewhat higher bit error rates due to interference).

Acconeer has attached a report,[18/] demonstrating that in the studied additive white Gaussian noise ("AWGN") cases the coding of the 802.11ad system makes it very robust to pulse radar interference, as only a very limited amount of the bits in any packet are interfered. Even with a very high interference level, the decoder is able to correct for the errors caused by interference. For this reason, 802.11ad devices would experience only a minor loss in performance even in the face of very high interference levels from pulse radars.

Calculations of the PER were performed for two cases with some simplifying assumptions. Case 1 considers short pulses and very high interference levels, while Case 2 considers long pulses and medium interference levels. In Case 1, the pulse is short so that only a single symbol is affected by a single pulse and the interference level is assumed so strong that

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17/ *See* Letter from Megan Anne Stull, Senior Counsel, Google LLC, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 21-48 (filed May 17, 2021) ("Google Ex Parte").

18/ *See* Appendix E ("Analytic calculation of the packet error rate of 802.11ad with pulse radar interference.")

the bit error rate is almost 50% when subjected to interference. In Case 2, the radar signals and the 802.11ad signals are equally strong but with a pulse length so that 6-7 symbols are affected per pulse. Acconeer's modeling shows that the 802.11ad system should be robust to pulse radar (and similar) interference, and with realistic radar parameters, the influence on the 802.11ad system should be limited.[19/]

In addition, Acconeer has attached interference measurement studies that were performed to demonstrate the findings of the analytical modeling studies.[20/] The study was done using commercially available 802.11ad devices and pulse radar. The conclusion is that no significant degradation of throughput to the 802.11ad system was observed even under extreme SIR values.

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19/ *See id.*

20/ *See* Appendix F ("Pulse radar to 802.11ad interference measurement study.").

## APPENDIX E – ANALYTIC CALCULATION OF THE PACKET ERROR RATE OF 802.11AD SUBJECT TO PULSE RADAR INTERFERENCE

In this appendix, we use an analytical framework for evaluating the packet error rate ("PER") of an 802.11ad single carrier system, after decoding, under interference from a pulse radar operating in the 60 GHz band. When evaluating the PER under such conditions, it is essential to consider that the interference affects only a limited fraction of the symbols in a packet. Hence, there will be a number of symbols unaffected by interference and a number of symbols affected by interference. The PER after decoding is the result of the bit error rates of the unaffected bits and the bit error rates of the affected bits. To make the translation from the two bit error rates to PER we use an approach used in the EU project MiWEBA from 2014,[21] where the full description of the framework can be found.

The link performance prediction is based on determining the function which maps multiple physical signal to interference and noise ("SINR") observations to a single "wide-band" metric which then can be converted to PER by means of a second mapping function (usually an AWGN reference). The physical layer abstraction method is based on the Mean Mutual Information per coded Bit ("MMIB") metric[22] and includes two steps:

- Calculation of MMIB metric for the given post-processing SINR values corresponded to each of the N symbols in the packet, *i.e.*, based on the signal to noise ratio ("SNR") for unaffected bits and SINR for affected bits; and
- MMIB to PER mapping.

[21] MiWEBA, Millimetre-Wave Evolution for Backhaul and Access, WP4: Radio Resource Management for mm-wave Overlay HetNets, D4.1: System Level Simulator Specification, Dec 2014.
[22] K. Sayana, J. Zhauang and K. Stewart, "Short term link performance modeling for ML receivers with mutual information per bit metrics," Proc. IEEE GLOBECOM 2008, Nov. 2008.

Given this analytical framework, the performance of a single carrier 802.11ad system under interference from a pulse radar now can be evaluated. The calculations are done under the assumption that the interference can be seen as additive white Gaussian noise, which will give a good indication of the system performance.

The ratio of 802.11ad symbols impacted by interference is given by

$$X_{interference} = f_p / R_{ad} * \max(1, \tau_p * f_p),$$

where $R_{ad}$ is the symbol rate of 802.11ad, $\tau_p$ is the pulse length, and $f_p$ is the pulse repetition frequency of the pulse radar. These symbols will experience an SINR that is worse than the SNR that the rest of the symbols will experience. The ratio of symbols in a packet not impacted by interference therefore is given by

$$X_{non\text{-}interference} = 1 - X_{interference} = 1 - f_p / R_{ad} * \max(1, \tau_p * f_p).$$

The MMIB is now calculated as a sum of $X_{interference}$*MMIB with SINR=Z and $X_{non\text{-}interference}$*MMIB with SNR=Y, and then the corresponding PER is derived.

### Case 1, high interference, short pulses

In the following case study, we assume a signal to interference ratio (“SIR”) of -30 dB, and vary the SNR and pulse repetition frequency. This scenario corresponds to a very high interference scenario so that the bit error rates for the symbols affected by interference is almost 50% and hence those symbols carry essentially no information.

**Figure 7** shows the analytical packet error rate for the 12 different modulation and coding schemes (“MCS”) in 802.11ad for a pulse repetition frequency of 13 MHz and SIR=-30 dB. The red curve shows the PER with interference, whereas the blue curve shows the PER without interference for comparison. As seen in the figure, the influence of the interference is marginal on the packet error rate under those settings.

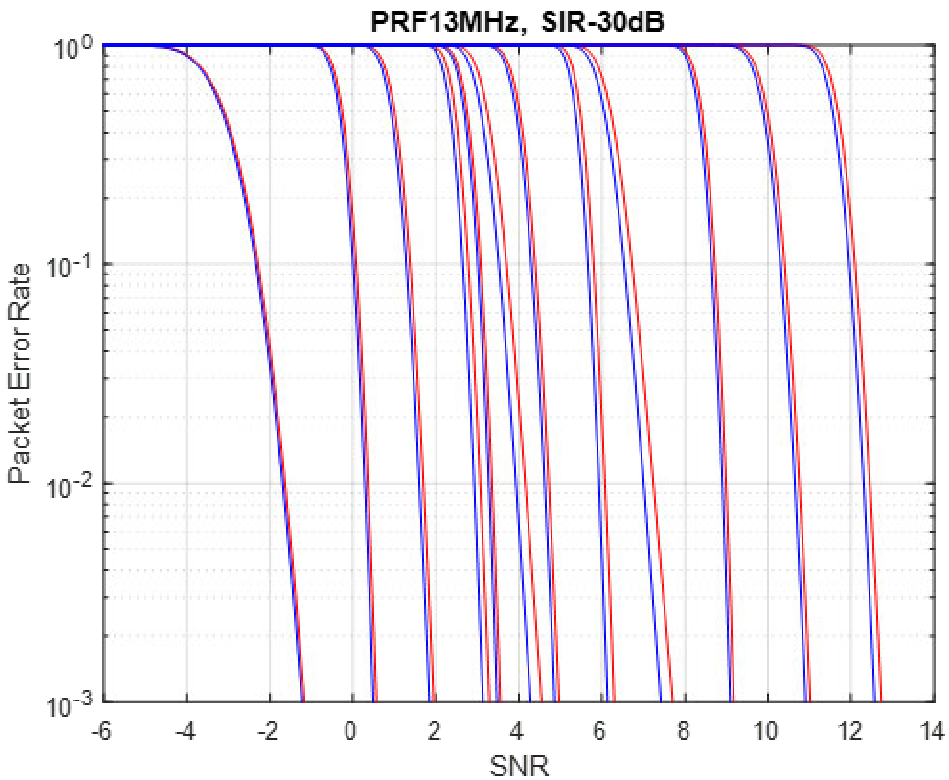


***Figure 7*** *Analytical packet error rate in an AWGN channel for the different MCS alternatives 1-12 for pulse repetition frequency 13 MHz and with a very high interference level, SIR=-30 dB. Red curve indicates the channel under interference, and the blue curve is without interference. Pulses are here 0.35 ns, hence shorter than the 802.11ad symbol time.*

### Case 2, medium interference, longer pulses

In the following analysis, we assume a signal to interference ratio ("SIR") of 0 dB and use longer pulses, $\tau_p$=3.6 ns. The longer pulses mean that on the average 6.3 of the 802.11ad symbols are affected by interference for every pulse, and with a pulse repetition frequency of 13 MHz, 4.7% of the 11ad symbols are affected by interference. Note that an SIR of 0 dB typically means that the radar is physically closer to the 802.11ad receiver than the 802.11ad transmitter due to the differences in antenna gains. If the radar is not aligned towards the 802.11ad receiver then the differences in distances can be rather large, with the radar even closer to the 802.11ad receiver.

**Figure 8** shows the packet error rate, and indicates that the influence of the pulse radar is only marginal to the performance of the 802.11ad system. For lower SNR values, there is essentially no influence as the SNR already is somewhat limited. For high SNRs, there is a slight performance loss and when being close to the boundary the 802.11ad system will back off to the closest but somewhat more robust MCS.

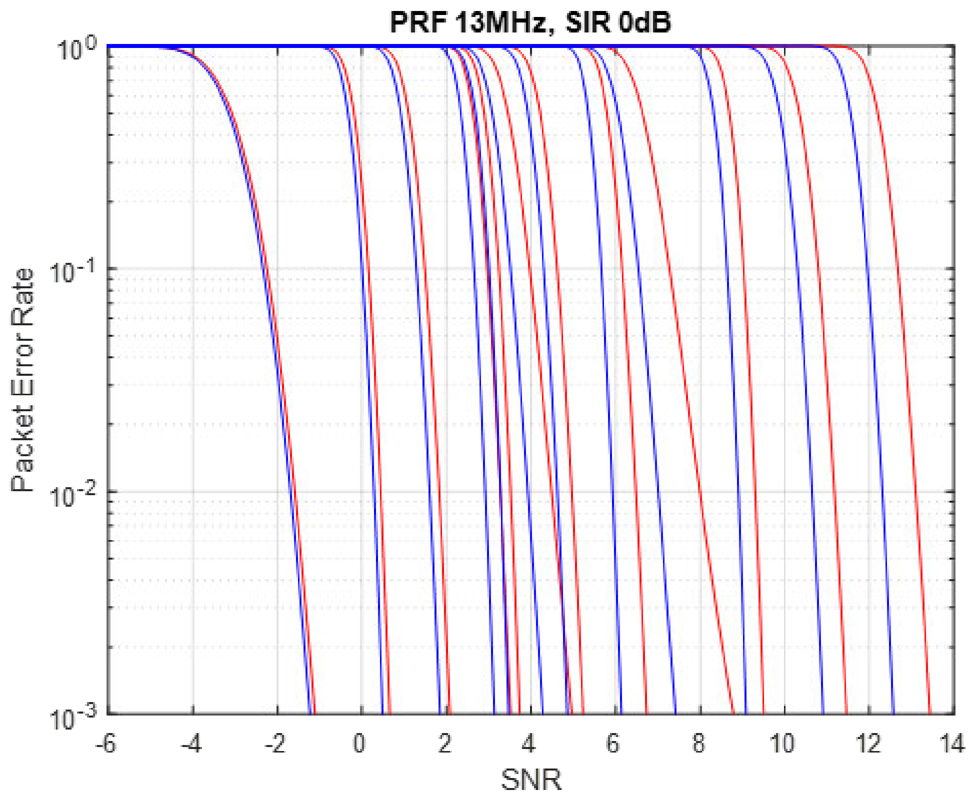


***Figure 8*** *Analytical packet error rate in an AWGN channel for the different MCS alternatives 1-12 for pulse repetition frequency 13 MHz and with a medium interference level, SIR=0 dB and longer pulses of 3.6 ns.*

## Conclusions

In the studied AWGN cases here, the coding makes the 802.11ad system very robust to pulse interference as only a part of the bits in a packet are interfered. Even with a very high interference level, the decoder is able to correct for the errors caused by interference. There is only a minor loss in performance even for very high interference levels.

Calculations of the PER have been shown for two cases with some simplifying assumptions, but the framework is general and can been used with various settings. Case 1 is for short pulses and very high interference levels, case 2 is for longer pulses and medium interference levels. In case 1, the pulse is short so that only a single symbol is affected by a single pulse, though the assumed interference level is so strong that the bit error rate would be almost 50% when subjected to interference. In case 2, the radar signals and the 802.11ad signals are equally strong but with a pulse length set so that 6-7 symbols are affected per pulse. Both of these evaluations demonstrate that an 802.11ad system should be robust to pulse-like interference and with realistic radar parameters the influence on the 802.11ad system should be limited.

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I HEREBY CERTIFY THAT I AM THE TECHNICALLY QUALIFIED PERSON RESPONSIBLE FOR THE PREPARATION OF THIS ANALYSIS, AND THAT IT IS COMPLETE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

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September 20, 2021

## APPENDIX F – PULSE RADAR TO 802.11AD INTERFERENCE MEASUREMENT STUDY

This measurement study investigates the interference from pulse radar to 802.11ad. Commercially available devices are used and the measurement setup is described in **Figure 9**.

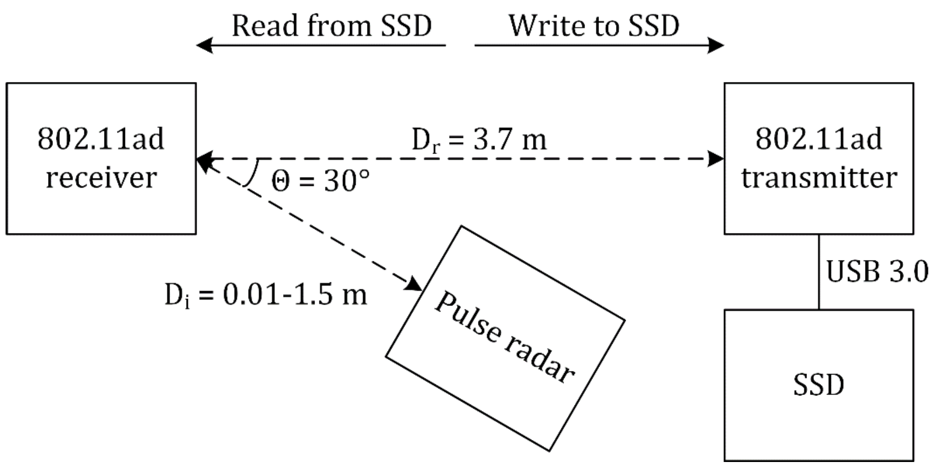


***Figure 9** Measurement setup*

The 802.11ad receiver is a Lenovo ThinkPad X270 PC with built-in WiGig Devices and the transmitter is a ThinkPad WiGig Docking station. The technical parameters of the 802.11ad equipment used is provided in **Table 6** and the technical parameters of the pulse radar equipment used is provided in **Table 7**.

***Table 6** Technical parameters of 802.11ad equipment used in interference measurement study*

| | |
|---|---|
| **Center frequency** | 60.48 GHz |
| **802.11ad channel** | CH2（59.40-61.56GHz） |
| **802.11ad transmitter EIRP** | 23 dBm （estimated from measurement） |
| **TX/RX CH Bandwidth** | 2.16 GHz |
| **Modulation** | SC-BPSK/QPSK/16QAM<br>(estimated from communication speed） |

*__Table 7__ Technical parameters of pulse radar used in interference measurement study*

| | |
|---|---|
| **Center frequency** | 60.5 GHz |
| **Pulse width** | 0.35, 0.8, 2.0, 3.6 ns |
| **Peak EIRP** | 17 dBm |
| **Calculated SIR at the 802.11ad receiver antenna according to setup in Figure 1, pulse radar at 0.05 m.** | -31 dB + alignment factor due to the directional characteristics of the 802.11ad receive antenna |

The result from the measurement study is shown in

**Figure 10**. No decrease in throughput is observed even when the pulse radar is as close as 5 cm to the 802.11ad receiver. When the pulse radar was placed 1 cm from the 802.11ad receiver, the reading speed decreased; however the writing speed was not impacted. The decreased reading speed is attributed to the fact that the pulse radar shielded the 802.11ad signal. If considering the effect of the SIR caused by the pulse radar signal, the necessary separation distance between the 802.11ad receiver and the pulse radar to ensure low interference is shown to be less than 5 cm based on the setup used in this study.

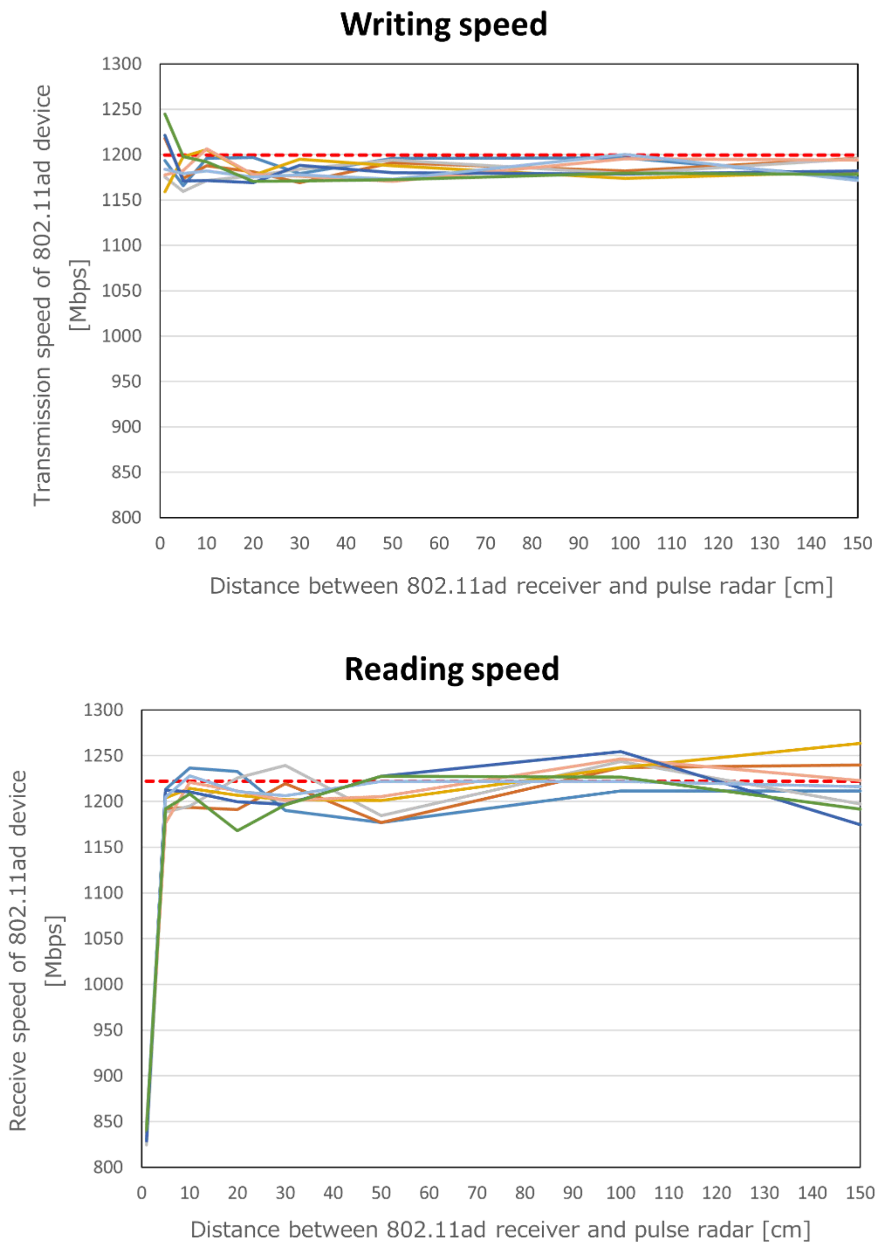


***Figure 10*** *Pulse radar to 802.11ad interference measurement study results. The calculated SIR at the 802.11ad receiver is -31 dB + alignment factor due to the directional characteristics of the 802.11ad receive antenna, when the pulse radar is positioned 5 cm from the 802.11ad receiver*

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I HEREBY CERTIFY THAT I AM THE TECHNICALLY QUALIFIED PERSON RESPONSIBLE FOR THE PREPARATION OF THIS ANALYSIS, AND THAT IT IS COMPLETE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

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