

Documents for the Record – 06.04.26 C&T Hearing

Where Are We?: Examining Positioning, Navigation, and Timing Capabilities in the United States

1. A June, 3 2026, letter to Chairman Guthrie from UPS.
2. A June 3, 2026, letter Committee leadership from tolling companies.
3. A June 4, 2026, letter from the Security Industry Association to Committee leadership.
4. A May, 26, 2026, letter from the Resilient Navigation and Timing Foundation to Committee leadership.
5. A June 3, 2026, letter from the Retail Industry Leaders Association to Committee leadership.
6. A June 4, 2026, letter from the RAIN alliance to Committee leadership.
7. Letters from fire safety officials to Committee leadership.
8. A June 2, 2026, letter from PrePass Safety Alliance to Committee leadership.
9. A June 4, 2026, letter from the National Retail Federation to Committee leadership.
10. A March 2, 2026, letter from TransCore addressed to Marlene H. Dortch at the Federal Communications Commission.
11. A June 3, 2026, letter from Edison International to Subcommittee leadership.
12. A June 3, 2026, letter from Frontiers of Freedom to Committee leadership.
13. A June 4, 2026, letter from Former Commander of the Air Force Space Commander General William L. Shelton to Committee leadership.
14. Kapsch Trafficcom Report of Laboratory Testing And Impact Analysis For Kapsch Nm-Lms Product Against Interference From Nextnav Proposed Usage Of The Lms Spectrum.
15. Test and Coexistence analysis report in the matter of Enabling Next-Generation Terrestrial Positioning, Navigation and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz) .
16. A June 3, 2026, letter from Iridium to Committee leadership.
17. A June 3, 2026, letter from the Internation Association of Fire Fighters to Committee leadership.
18. A June 4, 2026, statement for the record from the Edison Electric Institute.
19. A collection of letters, statements, and data regarding the June 4, 2026, Communications and Technology Subcommittee hearing.
20. A June 4, 2026, letter from the Electronic Security Association to Committee leadership.

21. A statement for the record from Digital Global Systems to the United States House of Representatives.
22. A June 3, 2026, letter to Chairman Brendan Carr from organizations that represent national security, public safety, and energy infrastructure industries.
23. A June 2, 2026, letter from the Bull Moose Project to Committee leadership.
24. A June 3, 2026, letter from the Information Technology & Innovation Foundation to Committee leadership.
25. A June 2, 2026, letter from the American Trucking Associations to Subcommittee leadership.
26. A June 2, 2026, letter from Jeffrey DeCoux of Atrius Industries to Committee leadership.
27. A June 4, 2026, letter from the Damage Prevention Action Center to Committee leadership.
28. An April 1, 2026, letter from the Information Technology Industry Council to Secretary Howard Lutnick.
29. RAIN NextNav Interference Analysis Study for RAIN Alliance Inc.
30. Statement of GS1 US for the Committee on Energy and Commerce of the United States House of Representatives, Subcommittee on Communications & Technology Hearing.

316 Pennsylvania Ave., SE
Suite 300
Washington, DC 20003



June 3, 2026

The Honorable Brett Guthrie
Chairman
House Committee on Energy and Commerce
2161 Rayburn House Office Building
Washington, DC 20515

Re: Opposition to NextNav Petition to Reconfigure 902–928 MHz Band

Dear Chairman Guthrie:

United Parcel Service (UPS) writes to express its opposition to NextNav’s petition to reconfigure the 902 to 928 MHz band. UPS supports efforts to strengthen national resilience through the development of complementary positioning, navigation, and timing (PNT) capabilities, including GPS backup systems. However, we are deeply concerned NextNav’s proposal would undermine the reliability of existing systems that a wide range of U.S. industries depend on for critical operations.

Across our network, UPS continues to make substantial, long-term investments in technology-driven logistics infrastructure. Key examples are the two new one-million square foot facilities in Bullitt County, Kentucky, where one million square feet is dedicated to healthcare supply chain solutions supporting the safe and timely delivery of medical products.¹ These operations depend on reliable, interference-free wireless systems to function effectively.²

UPS has invested more than \$100 million in radio frequency identification, or RFID, and sensor-based tracking technologies across its United States network.³ RFID uses radio waves to automatically identify and track tags attached to packages without requiring manual scanning.³ These systems enable continuous, real-time visibility of shipments, improving accuracy, efficiency, and workforce safety.

For healthcare shipments, these capabilities are essential. UPS Healthcare customers rely on RFID-enabled and sensor-linked systems to track high-value, time- and temperature-sensitive shipments such as vaccines, biologics, specialty pharmaceuticals, and critical medical devices.⁴ Through solutions such as UPS Premier, shipments can be monitored in real-time, allowing for proactive intervention when conditions place product integrity at risk.⁴

For patients, this translates directly into health outcomes. Many of these products are lifesaving or time-critical therapies that must arrive within strict temperature ranges and delivery windows. Disruptions to tracking technologies increase the risk of compromised medications, delayed treatments, or supply chain breakdowns that can affect hospitals, providers, and ultimately patients.

NextNav's proposal to reconfigure the 902 to 928 MHz band raises serious concerns because it introduces the potential for harmful interference in a spectrum already heavily used by RFID and logistics tracking systems.⁵ These systems are deployed at scale across healthcare and broader supply chains and are relied upon every day for patient-critical deliveries.

Industry analysis indicates that changes to this band could impose billions of dollars in costs and disrupt existing operations.⁵ For UPS, interference risks would undermine critical infrastructure, jeopardize healthcare shipments, and introduce uncertainty into supply chains relied upon by patients and providers. UPS urges the Committee and the Federal Communications Commission to preserve the integrity of the 900 MHz band and ensure that existing technologies, particularly those supporting healthcare delivery and patient safety, are protected from harmful interference.

UPS supports the continued development of resilient PNT solutions, including GPS backup systems, but urges policymakers to reject proposals that compromise existing, mission-critical infrastructure. For these reasons, UPS strongly opposes NextNav's petition.

Sincerely,

A handwritten signature in black ink that reads "Michael Kiely". The signature is written in a cursive, slightly slanted style.

Michael Kiely
President, Global Government Affairs, UPS

1 Kentucky Governor Press Release: <https://www.kentucky.gov/Pages/Activity-stream.aspx?n=GovernorBeshear&prId=1552>

2 WDRB Article: https://www.wdrb.com/news/business/state-of-the-art-ups-facility-coming-to-bullitt-county-expected-to-create-500-jobs/article_bcde0d20-83d2-11ee-84a7-8b45facba54b.html

3 Wall Street Journal: <https://www.wsj.com/logistics-report/ups-seeks-to-replace-manual-scans-with-tracking-tech-caf437db>

4 UPS Premier: <https://www.ups.com/md/en/healthcare/learning-center/articles/premier-sensor-linking>

5 Letter to Department of Commerce (RAIN Alliance Analysis referenced)



June 3, 2026

The Honorable Brett Guthrie
Chairman, House Committee on Energy and
Commerce

The Honorable Richard Hudson
Chairman, Communications and Technology
Subcommittee

The Honorable Frank Pallone
Ranking Member, House Committee on
Energy and Commerce

The Honorable Doris Matsui
Ranking Member, Communications and
Technology Subcommittee

Dear House Committee on Energy and Commerce Leaders:

The International Bridge, Tunnel & Turnpike Association (IBTTA) is the worldwide association for the owners and operators of toll facilities and the businesses that serve them. In the U.S., we represent the 134 toll operators in 33 states that operate some of the most critical assets in our national transportation system. These organizations process 10 billion transactions annually and are responsible for \$25 billion in toll revenue each year that is invested in operating, maintaining, and modernizing essential road infrastructure. E-ZPass is the largest interoperable electronic toll collection system in the world, commanding tremendous brand recognition through more than 30 years of distinguished customer service and unparalleled interoperability and reciprocity. We ask that you oppose a petition before the Federal Communications Commission (FCC) by NextNav, Inc. that would disrupt transportation services across the country, costing billions of dollars in lost revenue and increased expenses, while affecting mobility for millions of American citizens and businesses.

Electronic tolling has successfully used the lower 900 MHz band to advance safe, reliable, convenient, and assured toll collection for more than 35 years. The band allows motorists to use wireless devices in their vehicles to access the nation's tolled highways, bridges, and tunnels without the congestion, incidents, and delays of the past. NextNav's plan would reduce the spectrum available to tolling and many other consumer devices by more than 20%¹. Toll systems would be confined to operate in the middle of a new high-power service that will introduce harmful interference, directly degrading toll system performance.

For toll systems, the result would include missed transponder reads, greater dependence on less accurate collection methods, increased transaction costs, billing inaccuracies, revenue loss for infrastructure projects, reduced public trust, and downgraded bond ratings leading to higher debt costs for infrastructure investment.

For American consumers and businesses, the result would be more traffic congestion, backup, and delays; more fuel consumption, traffic incidents, and other costs from traffic congestion; billing errors, more collection by mail, and a loss of confidence in highly respected brands like E-ZPass, SunPass, FasTrak, and TollTag.

IBTTA and its members commissioned a study by Dr. Harold Furchtgott-Roth, an economist and former FCC Commissioner. Key findings showed that NextNav's proposed use of the spectrum imposes significantly greater economic costs than potential benefits. U.S. toll operations could

¹ Petition for Rulemaking of NextNav, Inc., WT Docket No. 24-240, April 16, 2024, p. 28.

initially face at least \$6.8 billion in economic losses from roadside and in-vehicle equipment impacts, degraded performance, lost revenue, and customer disruption². Engineering studies by three of the leading toll equipment manufacturers (Kapsch TrafficCom, Neology, and TransCore) demonstrate this damage and show that studies by NextNav claiming otherwise are based on faulty assumptions, methodologies, and conclusions.

NextNav seeks its new higher-power spectrum rights for free and without an auction, representing a huge government-granted subsidy. NextNav's proposal to lease most of the band to mobile carriers to subsidize its unprofitable position-navigation-and timing (PNT) network is an inefficient use of the spectrum and provides a financial windfall to a single commercial entity. There are more than a dozen alternative PNT technologies that could supplement GPS without requiring spectrum reallocation or creating widespread disruption and cost for government, industry, and the American public.³

Finally, all the damage that NextNav will cause will not even result in the nationwide GPS backup that NextNav holds as the reason for disrupting the country's toll systems. Leading navigation experts have demonstrated both that NextNav's technology is likely to never deliver on the company's promises and that there are several superior alternatives currently being evaluated by the Department of Transportation that would do the job better and more comprehensively.⁴

We urge you to protect American roads and motorists by opposing NextNav's spectrum plan.

Respectfully submitted,

/s/

Mark Chung
Executive Director and CEO
IBTTA
Washington, DC

/s/

/s/

Joi Taylor Dean
IBTTA President
CEO, Richmond Metropolitan
Transportation Authority
Richmond, VA

/s/

PJ Wilkins
Executive Director
E-ZPass Group
Newark, DE

/s/

James Hofmann
IBTTA Immediate Past President
Executive Director and CEO, North Texas
Tollway Authority
Plano, TX

² *An Economic Analysis of NextNav's Proposal for the Reallocation of Spectrum and the Modification of Rules in the Lower 900 MHz Band*, Harold Furchtgott Roth, April 2025, WT Docket 24-240, p. 20.

³ *Complementary PNT and GPS Backup Technologies Demonstration Report Sections 1 through 10*, U.S. Department of Transportation Volpe Center, January 2021 DOT-VNTSC-20-07,

⁴ *Technical Report, NextNav, Local Terrestrial Complement, Not Legitimate GPS Backup*, Mark Sturza, 3C Systems Company, February 6, 2026, WT Docket 24-240.

/s/

Minosca Alcantara
Executive Director, NY State Bridge
Authority
Highland, NY

/s/

Joseph Andl
Executive Director, Burlington County
Bridge Commission
Palmyra, NJ

/s/

Nicolas Barr
CEO, Indiana Toll Road Concession
Company
Elkhart, IN

/s/

Edward Barry
Toll Division Director, Washington State
Department of Transportation
Seattle, WA

/s/

James Bass
Executive Director, Central Texas Regional
Transportation Mobility Authority
Travis, TX

/s/

Lorenzo Rubio Beltrán
General Manager, Pocahontas Parkway
Richmond, VA

/s/

Anna Bonet
CEO, Elizabeth River Crossings, an Abertis
Company
Portsmouth, VA

/s/

Thomas A. Boyle, P.E.
CEO, Buffalo and Fort Erie Public Bridge
Authority
Fort Erie, ON, CA

/s/

Carlos Bracerias
Executive Director, Utah Department of
Transportation
Salt Lake city, UT

/s/

Stephen C. Brich, P.E.
Commissioner,
Virginia Department of Transportation
Richmond, VA

/s/

Andre J. Briere
Colonel, USAF (ret.), Executive Director,
Maine Turnpike Authority
Portland, ME

/s/

Ryan Chamberlain
CEO, Transportation Corridor Agencies
Irvine, CA

/s/

Mark Compton
CEO, Pennsylvania Turnpike Commission
Middletown, PA

/s/

Claudio Diaferia
Chief Operating Officer, Greater Miami
Expressway Agency
Miami, FL

/s/

Joe Donahue
Executive Director, E-470 Public Highway
Authority
Aurora, CO

/s/

James J. Eden
Executive Director, North Carolina Turnpike
Authority
Morrisville, NC

/s/

Joe Eschelle
Executive Director, Oklahoma Turnpike
Authority
Oklahoma City, OK

/s/

Andrew Fremier
Executive Director, Bay Area Toll Authority
and Metropolitan Transportation Comm.
San Francisco, CA

/s/

Kathryn Garcia
Executive Director, Port Authority of NY &
NJ
New York, NY

/s/

Bruce Gartner
Executive Director, Maryland
Transportation Authority
Baltimore, MD

/s/

Annie Gillespie
President, 6C Coalition
Atlanta, GA

/s/

Shanté A. Hastings, P.E.
Secretary, Delaware Department of
Transportation
Newark, DE

/s/

Frank G. Hoare, Esq.
Executive Director, New York State
Thruway Authority
Albany, NY

/s/

Darrell Johnson
Chief Executive Officer, Orange County
Transportation Authority
Orange, CA

/s/

Kris Kolluri
Executive Director, New Jersey Turnpike
Authority
Woodbridge, NJ

/s/

Mathieu P. Lisbonis
CEO, Northwest Parkway LLC
Broomfield, CO

/s/

Ananth Prasad
Chief Executive Officer, SH 130 Concession
Company
Buda, TX

/s/

Joseph J. Resta
Executive Director, Delaware River Joint
Toll Bridge Commission
Yardley, PA

/s/

Murali Ramanujam
Deputy Director - Toll Systems & Traffic
Engineering, Santa Clara Valley
Transportation Authority
San Jose, CA

/s/

Cassandra Rouse
Executive Director, Illinois State Toll &
Highway Authority
Downers Grove, IL

/s/

Catherine Sheridan
President, MTA Bridges and Tunnels
New York, NY

/s/

Lori Silveira
Executive Director, Rhode Island Bridge
Authority
Jamestown, RI



/s/

Greg Slater
CEO/Executive Director, Tampa
Hillsborough Expressway Authority
Tampa, FL

/s/

Stephanie Wiggins
CEO, LA Metro
Los Angeles, CA

/s/

Chuck Smith
Executive Director, West Virginia Parkways
Authority
Charleston, WV

/s/

Dennis Mulligan
General Manager & CEO,
Golden Gate Bridge, Highway &
Transportation District
San Francisco, CA

/s/

Luis Tejerina
CEO, Skyway Concession Company
Chicago, IL

Copy To: Members, House Energy and Commerce Committee



June 4, 2026

The Honorable Brett Guthrie
Chairman
House Committee on Energy & Commerce
2125 Rayburn House Office Building
Washington, DC 20515

The Honorable Frank Pallone
Ranking Member
House Committee on Energy & Commerce
2125 Rayburn House Office Building
Washington, DC 20515

The Honorable Richard Hudson
Chairman
Subcommittee on Communications &
Technology
2125 Rayburn House Office Building
Washington, D.C. 20515

The Honorable Doris Matsui
Ranking Member
Subcommittee on Communications &
Technology
2125 Rayburn House Office Building
Washington, DC 20515

Re: CMT Hearing: Where Are We?: Examining Positioning, Navigation, and Timing Capabilities in the United States

Dear Chairman Guthrie, Ranking Member Pallone, Chairman Hudson, and Ranking Member Matsui:

The Security Industry Association ("SIA") applauds the Communications & Technology Subcommittee for conducting a hearing on Positioning, Navigation, and Timing ("PNT") capabilities in the United States. As concerns grow about the potential for spoofing, jamming or inadvertent disruption of the Global Positioning System ("GPS"), it is critical for U.S. national and economic security to examine GPS alternatives.

Nonetheless, I write to express SIA's strong opposition to the proposal by NextNav, Inc. ("NextNav") to radically reallocate substantial portions of the 902-928 MHz Band (the "Lower 900 MHz Band") for a full-power 5G commercial system.¹ If its proposal is adopted, 60% of the Band would be allocated for NextNav's primary usage, drowning out critical life-safety uses.

SIA is a U.S. trade association representing more than 1,700 security solutions providers, ranging from large firms to locally owned and operated small businesses, whose members include manufacturers of security devices, alarm system communications, and electronic access control devices that operate within the Lower 900 MHz Band. Opposition to NextNav's proposal spans a broad swath of industries that touch Americans every day, including airlines, trucking, consumer technology, utilities, and telecommunications.

¹ *NextNav Petition for Rulemaking, Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz)*, WT Docket No. 24-240 (filed Apr. 16, 2024) ("NextNav Petition").

As the subcommittee examines PNT alternatives to GPS, we respectfully urge you and your colleagues to consider the devastating consequences the NextNav proposal would have on public safety, security systems, and the millions of Americans who rely on these devices every day. The United States has multiple PNT alternatives at its disposal that do not involve rendering billions of public safety and security devices inoperable, which is why the Federal Communications Commission (“FCC”) must reject the NextNav proposal.

The Lower 900 MHz Band Is Critical to Public Safety and Security

The Lower 900 MHz Band is heavily utilized by first responders and the security industry for an array of critical functions. These include “man down” systems, wireless microphones and headsets that help police and firefighters communicate during emergencies, gunshot detection systems, vehicle alerting systems that enable remote activation of lights and sirens, fire station automation relays, utility shutoffs in response to hazardous conditions, sensors used to monitor and control traffic during severe weather events, natural gas leak detection systems, and fire detection sensors in high-rise buildings.²

SIA’s members produce and deploy devices that are equally essential to public safety and the protection of homes, businesses, and critical infrastructure. These devices include smoke and carbon monoxide detection systems, doorbell cameras, panic alarms, home security systems, door locks, security camera and communications systems, and electronic access control devices that provide safety and security functions utilized by consumers, businesses, and first responders nationwide.

NextNav’s Proposal Would Render Critical Safety Devices Inoperable

NextNav’s proposed 5G cellular network would dramatically alter usage of the Lower 900 MHz Band by providing NextNav with a nationwide license for a 5G cellular network with a 10-megahertz downlink paired with a 5-megahertz uplink, meaning that nearly 60% of the Band would be allocated for primary usage by NextNav. The proposed downlink would transmit at roughly 4,000 watts, while current unlicensed Part 15 devices are limited to just 2.5 watts - that’s roughly 1,600 times more powerful than devices currently operating in the Band. This enormous power disparity would result in a severe reduction in the range and functionality of current Part 15 devices.

SIA commissioned an independent technical coexistence study conducted by Pericle Communications Company (“Pericle Report”) to evaluate the impact of the NextNav proposal.³ The Pericle Report conclusively demonstrates that NextNav’s proposed network and incumbent Part 15 devices simply cannot co-exist. The propagation modeling and Monte Carlo simulations employed in the study show that the deterioration in receiver sensitivity that would result from NextNav’s network, as well as ensuing co-channel and adjacent channel interference, would be so drastic as to make the Band unusable for incumbent unlicensed devices.

Specifically, the Pericle Report finds that outdoor unlicensed Part 15 devices using a 200 kHz bandwidth would need a signal to be, at a minimum, 538 times greater in order to overcome the interference from the NextNav network—effectively rendering these devices inoperable. The

² Letter from International Association of Fire Chiefs, et al, to Marlene Dortch, Secretary, FCC, WT Docket Nos. 24-240 and 25-110, Nov. 19, 2025 (“Public Safety Letter”).

³ Letter from Howard Waltzman, Counsel to the Security Industry Association, to Marlene Dortch, Secretary, FCC, WT Docket Nos. 24-240 and 25-100, Attachments 2 and 3, Sept. 12, 2025.

study's simulations further demonstrate that wireless cameras utilizing the Band and other similar representative connected devices would experience interference and blocking from NextNav's proposed network more than 60% of the time, even at a coverage radius of 2.0 km. At smaller coverage radii, the likelihood of interference is even greater—effectively stripping the devices of all utility.

The Practical Consequences Are Devastating

If approved, NextNav's proposal would mean that door locks will be unable to reliably communicate with corresponding alarm systems, many security cameras will be unable to communicate with remote monitoring systems, and smoke detectors may be unable to communicate with home hubs, meaning they will be unable to provide the fire and smoke alerts for which they are designed. Even temporary interference could result in gaping security vulnerabilities—for instance, if a window or door sensor misses a transmission due to interference, it could even result in a failure to trigger an alarm. With their communications impeded, security devices will be unable to promptly notify first responders of incidents, negating a crucial tool for first responders, who also use these devices for incident verification before dispatch.

NextNav's proposal would force existing Lower 900 MHz Band users, which currently share 26 MHz of spectrum, into just the roughly 40% of the Band that would not be controlled by NextNav. This would dramatically increase congestion in the remaining 11 megahertz of the Band, while subjecting such users to harmful interference from NextNav's much higher-power operations on adjacent frequencies. Furthermore, NextNav seeks the removal of the current requirement that it not cause unacceptable levels of interference to Part 15 devices—a remarkable admission that its proposal will, in fact, inflict such interference.⁴

Mitigation Is Not Possible

As the Pericle Report demonstrates, due to the high-power levels of NextNav's proposed system and the nature of the security devices that utilize the Lower 900 MHz Band, mitigation of NextNav's interference is simply not possible. The devices cannot be remotely reprogrammed or modified to accommodate the NextNav solution. Even if it were technically feasible to alter device operation, such a material change would in most cases require an entirely new chipset, meaning the devices would need to be entirely redesigned, physically removed, replaced, and re-installed. Additionally, a change in the operation of the device itself would also require a change to corresponding hub devices with which the devices communicate, meaning that entire systems would need to be completely replaced. With billions of devices installed nationwide, the monetary costs would be significant and the burden on consumers to replace the devices in their homes would be extreme.

Viable GPS Alternatives Exist That Do Not Harm Public Safety

SIA supports the identification and cultivation of terrestrial and other technologies that can provide a backstop against GPS vulnerabilities and ensure the continuity of PNT information for a multitude of U.S. industries. However, these solutions should be additive to the PNT ecosystem as a whole, augmenting existing functionalities rather than detracting from them by making public safety and security devices inoperable.

⁴ NextNav Petition at A-6, A-11.

Conclusion

The opposition to NextNav's proposal stretches across a wide spectrum of industries, including airlines, footwear, oil and gas, trucking, tolling, consumer technology, hydropower, retail, software, telecommunications, and utilities.⁵ SIA's opposition is grounded solely in the devastating consequences the proposal would inflict on the billions of devices nationwide that currently operate in the Lower 900 MHz Band—chief among them devices used for public safety, home safety and security, access control, and meter reading.

We urge the Committee to give serious consideration to the decimating impact of interference from the NextNav proposal to the billions of devices on which Americans depend. NextNav's proposal is simply not a viable one. We respectfully urge the Committee to relay to the FCC the serious concerns raised by NextNav's proposal, and that any solution for increasing the reliability of PNT infrastructure in the U.S. must not put at risk the critical public safety, security, and critical-infrastructure devices that currently operate in the Band. In short, NextNav's proposal should not be given further consideration.

SIA stands ready to provide any further information you might need as the important issue of PNT capabilities in the U.S. continues to be explored.

Sincerely,



Don Erickson

CEO

Security Industry Association

8455 Colesville Road, Ste. 1200

Silver Spring, MD

www.securityindustry.org

⁵ See, e.g., Comments of U.S. Chamber of Commerce et al, WT Docket No. 24-240, Sept. 5, 2024; see also Public Safety Letter; Letter from Aerospace Industries Association, Air Line Pilots Association, International, Airlines for America, et al, to Brendan Carr, Chairman, FCC, et al, WT Docket Nos. 24-240 and 25-100, Apr. 6, 2026; Comments of the Utilities Technology Council, WT Docket No. 24-240, Sept. 5, 2024; Comments of the Z-Wave Alliance, WT Docket No. 24-240, Sept. 5, 2024; Comments of the Edison Electric Institute, WT Docket No. 24-240, Sept. 5, 2024.



RNT Foundation
4558 Shetland Green Rd.
Alexandria, VA 22312

26 May 2026

Hon. Richard Hudson
Chairman, Subcommittee on Communications
2112 Rayburn House Office Building
Washington, DC 20515

Re: Hearing on NextNav's Petition before FCC

Dear Representative Hudson;

We are a public benefit scientific and educational charity advocating for policies and systems to protect GPS satellites, signals, and users. Our 65 member organizations represent nearly every facet of the positioning, navigation, and timing (PNT) industry and academia.ⁱ

The Global Positioning System (GPS) is essential to America's economic and national security. Yet it is vulnerable, and under attack. A terrestrial complement and backup is urgently needed.

NextNav, LLC has petitioned the Federal Communications Commission (FCC) for approximately \$5B worth of free spectrum to enable it to establish such a GPS backup system.

Last year the National Telecommunications Information Agency provided the FCC a list of over 50 companies offering PNT services to refute NextNav petition's false claim that they have the only solution.

As you consider this issue, we urge you to require the FCC to:

- Use fair and open competition before selecting any company to receive anything of value in exchange for provision of equipment and/or services to backup GPS,
- Clearly specify performance requirements - including accuracy, availability, continuity, integrity, resilience, and service area - when contracting for or agreeing to support an effort to establish a backup capability for GPS, and

- Work in close collaboration with the Department of Transportation and the Department of War because they, not the FCC, are responsible for leading the nation's PNT efforts. Previous efforts by one or two federal entities to establish a GPS backup capability have failed because they did not have sufficient consensus within the administration.

Thank you for your consideration.

Please let us know if we may be of further help in your deliberations.

Similar letters have been sent to Hon. Rick Allen and Hon. Doris Matsui.

Sincerely,

A handwritten signature in blue ink, appearing to read "Dana A. Goward".

Mr. Dana A. Goward
President

ⁱ We are technology neutral regarding solutions to complement and backup GPS. That said, we were compelled to file documents with the FCC to counter false and misleading statements NextNav included with its petition.



RETAIL INDUSTRY LEADERS ASSOCIATION

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www.rila.org

June 3, 2026

The Honorable Brett Guthrie
Chairman,
House Committee on Energy & Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Frank Pallone
Ranking Member,
House Committee on Energy & Commerce
U.S. House of Representatives
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The Honorable Richard Hudson
Chairman, Communications and Technology
Subcommittee,
House Committee on Energy & Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Doris Matsui
Ranking Member, Communications and
Technology Subcommittee,
House Committee on Energy & Commerce
U.S. House of Representatives
Washington, DC 20515

Dear Chair Guthrie, Chair Hudson, Ranking Member Pallone, and Ranking Member Matsui:

The Retail Industry Leaders Association (“RILA”) appreciates the opportunity to provide comments ahead of the Energy and Commerce’s Communication and Technology subcommittee hearing, “Where Are We?: Examining Positioning, Navigation, and Timing Capabilities in the United States.” We write to share significant concerns regarding NextNav’s Federal Communications Commission’s (FCC) petition¹ to reconfigure the 902-928MHz band (or the “Lower 900 MHz Band”), and highlight the impact such a reorganization will have for retailers and American consumers.

RILA is the U.S. trade association for leading retailers. We convene decision-makers, advocate for the industry, and promote operational excellence and innovation. Our aim is to elevate a dynamic industry by transforming the environment in which retailers operate. RILA members include more than 200 retailers, product manufacturers, and service suppliers, which together account for more than \$1.5 trillion in annual sales, millions of American jobs, and more than 100,000 stores, manufacturing facilities, and distribution centers domestically and abroad.

The lower 900MHz band is a historic U.S. natural resource and spectrum success story, helping spur American innovation and investment. For 30 years, FCC non-interference rules have allowed for the undisturbed deployment of licensed and unlicensed users on this band, backed by billions of dollars of investment in building out these devices and services to specifically operate on this piece of spectrum. As emphasized by the multitude of stakeholder filings within the FCC docket, the band now supports an active and diverse environment: first responders, medical alert devices, public utility infrastructure, railroad safety systems, home security devices, supply chain logistics, transportation and tolling systems, amateur radio operators, and the Internet of Things (IoT) ecosystem rely on this band and enable businesses and public services to provide everyday amenities to the communities they serve.

¹ NextNav Petition for Rulemaking, Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz), Public Notice, WT Docket No. 24-240 (rel. Aug. 6, 2024) (“Public Notice”). <https://www.fcc.gov/ecfs/search/docket-detail/24-240>.

The NextNav petition threatens this symbiosis. NextNav aims to fundamentally overhaul the lower 900Mhz band and repurpose its core for a new, nationwide fifth generation (5G) terrestrial-based positioning, navigation, and timing (PNT) network to serve as an alternative to the current U.S. Global Position System (GPS). All stakeholders wholeheartedly agree that the need for backup alternatives to GPS are readily apparent, with recent jamming and spoofing of GPS signals seen in the Russia-Ukraine War as well as China's regular jamming in the South China Sea.² Nevertheless, the means by which NexNav seeks to accomplish its goals are less than agreeable.

NextNav's proposed reconfiguration would compress current users to the middle of the lower 900MHz band (907-918MHz), cutting the block of incumbent spectrum from 26MHz to only 11MHz. Shrinking available spectrum by more than half would mean more congestion, fewer channels, and degraded performance for widely used technologies. Were the interference too great, the direct cost of replacing RFID systems that end users rely on for inventory and logistics alone is estimated to be between \$5 billion to \$7.2 billion.³

The costs and energy associated with NextNav's proposal are simply too great given that viable alternative options exist and are currently being evaluated.⁴ Its proposal to reconfigure this piece of spectrum will have significant economic and operational costs for a large swath of the American economy with limited and uncertain benefits in return. Moreover, these costs are not merely theoretical: they would be borne directly by businesses, state and local governments, and ultimately American consumers through higher prices, degraded services, and disrupted critical systems.

We appreciate the Committee's attention and leadership to examining U.S. PNT capabilities in finding an alternative to GPS and stand ready to assist wherever appropriate.

Please direct questions or requests for further information about this comment letter to Justin Goldberger, Vice President of Technology Policy, at justin.goldberger@rila.org.

² GPS World, *Innovation: Recent GPS Jamming in Regions of Geopolitical Conflict*, <https://www.gpsworld.com/innovation-recent-gps-jamming-in-regions-of-geopolitical-conflict/> (last visited May 26, 2026). Resilient Navigation & Timing Foundation, *Comms GNSS Interference in South China Sea* (Mar. 6, 2023), <https://rntfnd.org/2023/03/06/comms-gnss-interference-south-china-sea/>.

³ RAIN Alliance Ex Parte, FCC, WT Docket Nos. 24-240, 25-110 (Mar. 9, 2026). Letter from Aileen Ryan, RAIN Alliance, to Marlene H. Dortch, Sec'y, FCC, re: Notice of Inquiry – Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions, WT Docket No. 25-110 (Mar. 9, 2026) (transmitting RAIN Economic Impact Study).

⁴ See Hellen Systems, *Our Technology*, <https://hellensystems.com/our-technology/> (last visited May 26, 2026); see also, Federal Communications Commission, *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, Notice of Inquiry, WT Docket No. 25-110 (adopted Mar. 27, 2025); see also, Advanced Television Systems Committee, *ATSC 3.0 Standards*, <https://www.atsc.org/atsc-documents/type/3-0-standards/> (last visited May 26, 2026).





June 4, 2026

The Honorable Brett Guthrie
Chairman, Committee on Energy and Commerce
U.S. House of Representatives
2161 Rayburn House Office Building
Washington, DC 20515

The Honorable Frank Pallone, Jr.
Ranking Member, Committee on Energy and
Commerce
U.S. House of Representatives
2107 Rayburn House Office Building
Washington, DC 20515

The Honorable Richard Hudson
Chairman, Subcommittee on Communications
and Technology
U.S. House of Representatives
2112 Rayburn House Office Building
Washington, DC 20515

The Honorable Doris Matsui
Ranking Member, Subcommittee on
Communications and Technology
U.S. House of Representatives
2206 Rayburn House Office Building
Washington, DC 20515

Dear Chairman Guthrie, Ranking Member Pallone, Chairman Hudson, Ranking Member Matsui, and Distinguished Members of the Subcommittee on Communications and Technology:

I write regarding the June 4, 2026, House Energy and Commerce Committee, Subcommittee on Communications and Technology hearing, "Where Are We?: Examining Positioning, Navigation, and Timing Capabilities in the United States."

The RAIN Alliance fully supports the development of a reliable, independent alternative to GPS-based Positioning, Navigation, and Timing (PNT). A resilient PNT infrastructure is a legitimate national priority, and we stand ready to work constructively with Congress and the FCC toward that goal.

However, that objective cannot be achieved at the expense of the lower 900 MHz spectrum band, which is home to a rich ecosystem of innovative technologies crucial to the U.S. economy, public health, and national security, and that enable U.S. enterprises to compete and win globally. Granting a single company a spectrum windfall at the expense of these proven, productive technologies is neither sound policy nor in the public interest. The RAIN Alliance calls on Congress and the FCC to pursue GPS resiliency solutions that strengthen America without dismantling the infrastructure that underpins critical sectors of the U.S. economy and national security.

THE RAIN ALLIANCE

The RAIN (Radio Identification) Alliance is the global industry organization for Ultra High Frequency (UHF) Radio Frequency Identification (RFID) technology, also known commercially as RAIN RFID, which operates under the ISO/IEC 18000-63 standard. Our members span chip makers, reader and antenna manufacturers, systems integrators, retailers, hospitals, military logistics operators, and manufacturers who deploy RAIN at scale. The scale of this industry is significant: the RAIN Alliance reported 52.8 billion RAIN RFID tags shipped globally in 2024 alone, more than one billion per week.¹ Annual shipments are projected to

¹ RAIN Alliance, "Report: Shipments of 52.8bn RAIN Tag Chips Globally in 2024" (February 26, 2025), [therainalliance.org: https://therainalliance.org/rain-alliance-report-shipments-of-52-8bn-rain-tag-chips-globally-in-2024/](https://therainalliance.org/rain-alliance-report-shipments-of-52-8bn-rain-tag-chips-globally-in-2024/)

surpass 115 billion by 2029.² Every one of those tags, and every RAIN reader and antenna deployed in the United States, operates exclusively in the 902–928 MHz band. There is no substitute for this innovation band as designated by the FCC’s Part 15 and Part 18 ISM framework for over four decades.³

WHAT’S AT STAKE

NextNav, Inc. has petitioned the FCC to restructure the lower 900 MHz band in its favor: a nationwide 15-megahertz flexible-use license, operating at power levels up to 3,280 W/MHz EIRP, orders of magnitude above current Part 15 limits. This change would relegate all existing unlicensed users to secondary status in a compressed fraction of the current spectrum. The consequences of taking such an action are well documented. The findings of the RAIN Alliance’s own independent technical study and the economic impact analysis of former FCC Commissioner Harold Furchtgott-Roth illustrate the breadth of American industries that would be harmed, not to mention the geopolitical implications of ceding American leadership in UHF RFID technology to eager Chinese competitors.

The opposition to this petition is extraordinary in its breadth and depth. Over 2,000 comments have been filed with the FCC, and virtually every filer other than NextNav itself and a small number of its commercial allies opposes the petition, representing almost every sector of the American economy that relies on shared, unlicensed wireless spectrum. Tellingly, not a single consumer group, wireless carrier, broadband provider, or major GPS advocacy organization has endorsed the NextNav Petition.⁴

INDUSTRIES IMPACTED

The lower 900 MHz band is one of the most productive and economically vital unlicensed bands in the United States, despite NextNav’s claim that it is an underutilized spectrum backwater. The U.S. Chamber of Commerce, filing on behalf of a broad industry coalition, summarized the record: the band is intensively used by customers of “broad sectors of the economy, including operations involving retail, critical infrastructure, aviation, electrical utilities, oil, natural gas, railroads, highway tolling, broadband, smart home devices, security, public safety, and supply chain.”⁵

² RAIN Alliance / VDC Research, *RAIN RFID 2024 Market Research Report* (June 2024), [therainalliance.org: https://therainalliance.org/rain-rfid-2024-market-report/](https://therainalliance.org/rain-rfid-2024-market-report/)

³ 47 C.F.R. §§ 15.247, 15.249; *see also* 47 C.F.R. Part 18 (governing ISM device operations in the 902–928 MHz band). The Part 15 framework has been described by the Commission as “highly successful in fostering the development of new unlicensed devices while protecting authorized users of the radio spectrum from harmful interference.” *Amendment of Parts 2 and 15 of the Commission’s Rules for Unlicensed Devices*, Memorandum Opinion and Order, FCC 07-117, ¶ 2 (rel. June 22, 2007).

⁴ NextNav Inc., Petition for Rulemaking, *Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz)*, WT Docket No. 24-240, RM-11989 (filed Apr. 16, 2024), available at <https://www.fcc.gov/ecfs/document/10416238018537/1>; *see also* FCC Public Notice, *Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking*, DA 24-776, 39 FCC Rcd 8695 (rel. Aug. 6, 2024), available at <https://docs.fcc.gov/public/attachments/DA-24-776A1.pdf>.

⁵ U.S. Chamber of Commerce et al., Reply Comments, WT Docket No. 24-240 (Sept. 20, 2024), available at <https://www.uschamber.com/technology/nextnav-petition-coalition-reply-comments>

The following table summarizes the industries impacted, the organizations that have filed in opposition, and the specific harm each sector faces:

Industry / Sector	Impact of NextNav Petition if Granted
UHF RFID / Supply Chain	RAIN RFID is the backbone of U.S. retail, logistics, healthcare, and national security. RAIN Alliance , AIM Global , Avery Dennison , Impinj , Zebra Technologies , r-pac International , and GS1 US warn that interference would degrade or terminate RFID operations, stranding billions in deployed infrastructure and disrupting supply chains with global consequences.
Public Safety & Emergency Response	APCO International , the International Association of Fire Chiefs (IAFC) , the International Association of Chiefs of Police (IACP) , and the National Sheriffs' Association jointly documented that NextNav's proposed operations would directly interfere with devices used in public safety dispatch, emergency response coordination, and first responder tracking.
Alarm & Life-Safety Devices	The Security Industry Association (SIA) , the Alarm Industry Communications Committee (AICC) , and The Monitoring Association (TMA) represent tens of millions of fire alarms, carbon monoxide detectors, flood sensors, panic buttons, and motion detectors operating in this band. The SIA-commissioned Pericle technical study confirmed harmful interference would result.
Electronic Access Control & Security	SIA , the Builders Hardware Manufacturers Association , and the EnOcean Alliance warn that keyless entry, electronic locks, and access control systems for schools, hospitals, and government buildings would face unacceptable interference, increasing security risks and costs.
Highway Tolling & Transportation	The International Bridge, Tunnel and Turnpike Association (IBTTA) represents approximately 120 million electronic tolling transponders (6C standard) used at tens of thousands of tolling points nationwide. In 2023, U.S. electronic tolling generated tens of billions in revenue. The PrePass Safety Alliance, the Wisconsin Motor Carrier Association, and state toll agencies — including the Golden Gate Bridge District — filed comments warning of severe interference to toll collection systems and weigh station bypass programs.

Electric Utilities & Smart Grid	The Edison Electric Institute and Dominion Energy documented that the electric power industry relies on this band for smart meters, Advanced Metering Infrastructure (AMI), and SCADA systems that control grid operations. Interference could jeopardize utility reliability and critical infrastructure protection.
Railroads	The Association of American Railroads joined the U.S. Chamber letter highlighting railroad industry relies on 900 MHz communications for switching, control systems, and safety operations. Industry representatives filed noting that NextNav's proposed high-power operations could disrupt rail communications with direct safety implications.
Smart Home & IoT / Z-Wave	The Z-Wave Alliance estimates more than 100 million non-spread spectrum Z-Wave smart home devices are deployed in the U.S. The Wi-Fi Alliance , Wi-SUN Alliance , and LoRa Alliance document that smart home automation, industrial monitoring, smart city infrastructure, and agricultural IoT devices — including Amazon Sidewalk — would be forced into a severely crowded residual band.
Aviation & Airlines	Airlines for America documented that multiple airlines depend on RFID tagging in the 900 MHz band for inventory control of critical safety-related aircraft parts, as well as passenger baggage handling. Interference could cause flight delays and baggage mishandling at scale.
Broadband / Rural Internet	WISPA — The Association for Broadband Without Boundaries — warned that the petition would constrain fixed wireless providers from delivering broadband service in rural and underserved areas, directly undercutting national broadband goals. NextNav's proposal provides no credible expansion of broadband service to offset this harm.
Oil, Gas & Industrial	Industrial operators in the oil and gas sector rely on 900 MHz for tank and leak monitoring, pipeline SCADA, fleet management, and asset protection systems. These systems cannot be easily retuned or migrated, and interference could pose both economic harm and industrial safety risks. The Utilities Technology Council highlighted concerns.
Agriculture	Smart agriculture applications — including soil monitoring, irrigation control, crop sensors, and livestock tracking — depend on the 900 MHz band's long-range, low-power characteristics. The Wi-Fi Alliance and

	commenters at the Consumer Technology Association highlighted agricultural IoT as a primary casualty of band reconfiguration.
Automotive	Honda /Acura filed comments documenting that keyless entry systems in its vehicles operate in the 900 MHz band. Reconfiguration could force costly redesigns and consumer inconvenience across a broad installed base of vehicles.
Medical Devices & Healthcare	Medical device manufacturers and healthcare systems use 900 MHz for patient monitoring, medication management, and asset tracking. The U.S. RFID healthcare market is projected to reach \$5.24 billion by 2030. According to Cardinal Health , disruption to RAIN RFID in hospitals would impair patient safety and operational efficiency.
Consumer Electronics	The Consumer Technology Association noted that the 900 MHz band powers consumer innovation showcased at CES, including long-range smart home devices. Public Knowledge and New America's Open Technology Institute warned the proposal would "decimate" the band and cost hundreds of millions of consumers and businesses that depend on unlicensed innovation.
Government / Defense	NTIA filed asking the FCC to defer action on the petition until sufficient details are available on how NextNav will not cause harmful interference to incumbent users. The DoW has required passive UHF RFID tagging on military shipments since January 2005 under MIL-STD-129R. Military logistics, supply chain verification, and asset accountability programs depend on unimpeded access to the 902–928 MHz band. Inovonics documented that 900 MHz devices currently protect Members of Congress, state legislators, TSA agents, and U.S. embassies.
National Electrical Mfrs. / NEMA	The National Electrical Manufacturers Association (NEMA) filed opposition documenting that electrical products, building automation systems, and industrial controls that rely on 900 MHz unlicensed spectrum would face harmful interference and potential operational failure.

The breadth of this opposition is without precedent in recent spectrum proceedings. As the U.S. Chamber of Commerce coalition concluded: "Moving forward with this flawed proposal would distract FCC resources, risk harming millions of consumers and businesses, and lacks a clear public interest."⁶

⁶ Ibid.

LS TELCOM STUDY and TECHNICAL ANALYSIS

The RAIN Alliance retained LS telcom, an internationally recognized independent spectrum engineering firm, to conduct a rigorous technical analysis of the interference that would result from NextNav's proposed operations.⁷ The LS telcom study reached unambiguous conclusions, finding that NextNav's proposed operations and RAIN RFID are effectively incompatible in the same band. RAIN RFID devices would cause severe interference to NextNav's proposed 5G uplink, while NextNav's proposed high-power operations would cause localized interference to RAIN RFID systems. The findings are supported by other technical studies, including the Plum Report⁸ and the Pericle Coexistence Study.⁹ Both conclude that NextNav's proposed operations would result in significant harmful interference to both Part 15 users and NextNav itself. NextNav has failed to respond to these interference concerns.

While the PNT solution proposed by NextNav is expected to utilize only a small portion of the spectrum they seek (approximately 5%, the remaining spectrum would be subleased to a high-powered 5G provider), NextNav's solution would be subject to interference from existing unlicensed users, resulting in a full failure of the PNT alternative proposed by NextNav.¹⁰ NextNav has yet to acknowledge that interference,¹¹ let alone how existing unlicensed users would be identified and addressed.

Additionally, the RAIN Alliance's April 18, 2025, analysis further found that NextNav's own February 2025 coexistence study is fundamentally flawed: it addresses only two of eight potential interference scenarios; employs self-serving assumptions about antenna heights, propagation models, and building penetration losses that systematically understate interference; and makes factually incorrect assumptions about how RAIN RFID technology operates.¹² NextNav has produced no verified field measurement data from real-world deployments to support their claims. The weight of independently verified technical evidence in opposition to NextNav's claims in this record is overwhelming and undeniable.

On May 4, 2026, NextNav published a promotional test video and accompanying blog post purporting to demonstrate compatibility between its proposed 5G operations and RAIN RFID systems in the lower 900

⁷ LS telcom, Independent Technical Analysis of Interference from NextNav Proposed Operations in the 902–928 MHz Band, filed on behalf of the RAIN Alliance, WT Docket No. 24-240.

⁸ Plum Consulting, Assessment of the NextNav Inc. Coexistence Study, jointly filed by RAIN Alliance, LoRa Alliance, Z-Wave Alliance, Wi-Fi Alliance, and Wi-SUN Alliance, WT Docket Nos. 25-110 and 24-240 (Apr. 28, 2025).

⁹ Security Industry Association and Pericle Communications Company, Radio Coexistence Study Between Lower 900 MHz Incumbents and Potential 5G Network (Sept. 9, 2025), WT Docket Nos. 24-240 and 25-110.

¹⁰ NextNav Inc., Petition for Rulemaking, Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz), WT Docket No. 24-240, RM-11989 (filed Apr. 16, 2024), available at <https://www.fcc.gov/ecfs/document/10416238018537/1>; see also FCC Public Notice, Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking, DA 24-776, 39 FCC Rcd 8695 (rel. Aug. 6, 2024), available at <https://docs.fcc.gov/public/attachments/DA-24-776A1.pdf>.

¹¹ NextNav Inc., *NextNav Analysis of RAIN Alliance's LS telcom Study*, filed as attachment to Letter from NextNav Inc. to Marlene H. Dortch, Secretary, FCC, WT Docket Nos. 24-240 and 25-110 (Jun. 2026), available at <https://www.fcc.gov/ecfs/document/1060279388274/1>

¹² RAIN Alliance, Analysis of NextNav Technical Report, WT Docket No. 24-240 (Apr. 18, 2025).

MHz band.¹³ These materials are wholly inadequate. Rather than providing a rigorous technical rebuttal to the interference findings already in the FCC record, NextNav's demonstrations rely on narrow, highly controlled scenarios that bear little resemblance to the complex, interference-rich environments in which RAIN RFID systems operate across retail, healthcare, defense, and logistics.¹⁴

Critically, the materials fail entirely to address interference flowing from widespread RAIN RFID operations into NextNav's proposed network, a central coexistence concern independently documented in technical studies already before the Commission.¹⁵ The methodology, measurement conditions, and raw data necessary for independent verification are absent. NextNav's promotional materials do more to expose the gaps in the company's coexistence strategy than to resolve them, and they provide no basis for the Commission to discount the substantial, independently verified technical record in opposition.

ECONOMIC IMPACT

The RAIN Alliance commissioned Harold W. Furchtgott-Roth, former FCC Commissioner and a former chief economist for the House Energy and Commerce Committee, to conduct an independent economic assessment of the costs NextNav's proposal would impose on the RAIN RFID industry. The findings conclude that the RAIN RFID industry alone would face between \$5.0 billion and \$7.2 billion in direct replacement costs – before accounting for substantial unquantifiable indirect costs and additional harms.¹⁶ Ultimately, all of these increased costs will filter down to the U.S. consumer at a time when they can least afford them.

NextNav filed a rebuttal by the Brattle Group, claiming that costs to unlicensed users would be “approximately zero.”¹⁷ That conclusion is farcical as it presupposes that NextNav's operations will not cause interference, the very premise that LS telcom, Plum Consulting, Pericle, and five wireless alliances have independently proven in the record.¹⁸ A zero-cost estimate built on a factually discredited interference assumption is not an economic analysis — it is wishful thinking and spin masquerading as analysis.

¹³ NextNav Inc., *Seeing Is Believing: NextNav Demonstrates 5G and RFID Coexistence in the Lower 900 MHz Band*, NextNav Blog (May 4, 2026), <https://nextnav.com/demonstrating-5g-and-rfid-coexistence-in-the-lower-900-mhz-band/>.

¹⁴ RAIN Alliance, GS1 US & AIM Global, *RAIN Alliance, GS1 US, and AIM Global Respond to NextNav Testing*, RAIN Alliance (May 2026), <https://therainalliance.org/rain-alliance-gs1-and-aim-global-respond-to-nextnav-testing/>.

¹⁵ LS telcom, Independent Technical Analysis of Interference from NextNav Proposed Operations in the 902–928 MHz Band, filed on behalf of the RAIN Alliance, WT Docket No. 24-240.

¹⁶ Harold W. Furchtgott-Roth, *Economic Impact Study*, Furchtgott-Roth Economic Enterprises (Feb. 2026), filed on behalf of the RAIN Alliance, WT Docket No. 24-240, FCC ECFS Document No. 103091335301841 (Feb. 2026), available at <https://www.fcc.gov/ecfs/document/103091335301841/2>.

¹⁷ The Brattle Group, *Second Supplemental Economic Analysis on Behalf of NextNav, Inc.*, filed as attachment to Letter from NextNav Inc. to Marlene H. Dortch, Secretary, FCC, WT Docket Nos. 24-240 and 25-110 (Nov. 2025), available at https://www.fcc.gov/ecfs/search/search-filings?proceedings_name=24-240;

¹⁸ See LS telcom, Independent Technical Analysis, WT Docket No. 24-240 (filed on behalf of RAIN Alliance); Plum Consulting, Assessment of the NextNav Inc. Coexistence Study, WT Docket Nos. 24-240 and 25-110 (Apr. 28, 2025); Pericle Communications Company, Radio Coexistence Study Between Lower 900 MHz Incumbents and Potential 5G Network, WT Docket Nos. 24-240 and 25-110 (Sept. 9, 2025) (filed on behalf of the Security Industry Association);

The reason NextNav can make this claim is revealing: NextNav has explicitly asked the FCC to eliminate the very Part 15 rules that currently protect unlicensed device operators from claims about causing harmful interference to licensed services in the band.¹⁹ This safe harbor has shielded hundreds of millions of innovative devices operating in the lower 900 MHz band for decades. In other words, NextNav's interference cost estimate is zero because NextNav intends to make interference from unlicensed users legally irrelevant, not because its operations will not be subject to harmful interference. The Committee and the FCC should give Brattle Group analysis zero weight.

U.S. COMPETITIVENESS

If the FCC grants NextNav's petition and disrupts the U.S. RAIN RFID market, American manufacturers, who are currently leading the world, will lose the domestic foundation that underpins their global competitiveness, and standards leadership will shift from the ISO/IEC 18000-63 framework the U.S. has led in helping the RAIN Alliance build over decades to a Chinese-backed alternative, precisely the outcome U.S. trade and technology policy should be working to prevent.²⁰

Congress should be aware that weakening RAIN RFID in the United States carries a direct competitive cost. Huawei, OPPO, ZTE, and China Mobile spearheaded a competing battery-free item-identification standard — 3GPP Ambient IoT (A-IoT) into international standards bodies in 2021, and it targets the identical applications as RAIN RFID: retail inventory, logistics, warehousing, and supply chain tracking.²¹ 3GPP Release 19, finalized in 2025, formally adopts Ambient IoT as a new device class, and Chinese operators have already demonstrated platform support.²²

see also Z-Wave Alliance, LoRa Alliance, Wi-Fi Alliance, Wi-SUN Alliance, and RAIN Alliance, Joint Technical Analysis, WT Docket Nos. 24-240 and 25-110 (Apr. 2025).

¹⁹ NextNav Inc., Petition for Rulemaking, *Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz)*, WT Docket No. 24-240, RM-11989, at 38–42 (filed Apr. 16, 2024), available at <https://www.fcc.gov/ecfs/document/10416238018537/1> (proposing to modify or eliminate the interference protection obligations currently afforded to Part 15 unlicensed device operators under 47 C.F.R. §§ 15.247, 15.249, and to remove the existing field-testing safe-harbor requirement that M-LMS licensees, including NextNav, must currently satisfy before operating at increased power levels); see also Protect the Lower 900 MHz Band, Security Industry Association (Apr. 2025) (documenting NextNav's proposal to remove field-testing requirements that protect incumbent unlicensed users).

²⁰ 3GPP, *Ambient IoT in Release 19* (finalized Dec. 2025), <https://www.3gpp.org/technologies/rel19-aiot> (targeting "inventory management and command" using battery-free backscatter technology — the identical design and use cases as RAIN RFID); Rodrigo Balbontin, *Backfire: Export Controls Helped Huawei and Hurt U.S. Firms*, ITIF (Oct. 27, 2025), <https://itif.org/publications/2025/10/27/backfire-export-controls-helped-huawei-and-hurt-us-firms/> (U.S. actions against Huawei cost American firms \$33 billion in lost sales while Huawei's global market share grew — demonstrating that unilateral U.S. policy decisions intended to weaken Chinese competitors can instead accelerate their dominance).

²¹ Abi Research, "Could Passive IoT Be the Killer App for 5G-Advanced?" (May 2, 2023), abiresearch.com (Huawei introduced Ambient IoT to 3GPP June 2021); IDC, "Ambient IoT: 5G's Smallest Devices May Make a Massive Impact" (Dec. 16, 2025), [idc.com](https://www.idc.com); 3GPP, Release 19 Ambient IoT, <https://www.3gpp.org/technologies/rel19-aiot>.

²² IDC (Dec. 16, 2025) ("Chinese operators have shown that connectivity management platforms can support [Ambient IoT]"); Mingxi Yin et al., "Low-Complex Waveform, Modulation and Coding Designs for 3GPP Ambient IoT," arXiv:2501.08555 (Jan. 2025).

CONCLUSION

The record before the FCC in WT Docket No. 24-240 is definitive. The LS telcom technical study, among others, demonstrates severe, irreversible interference both to and from RAIN RFID. The Furchtgott-Roth analysis documents costs that outweigh benefits by up to 28:1. More than seventeen distinct sectors of the American economy, from public safety and defense to retail, agriculture, aviation, and railroads, have filed in opposition. And the rise of Chinese-backed 3GPP Ambient IoT makes plain that weakening U.S. leadership in RAIN RFID is not a neutral regulatory act: it is a concession of technological leadership to foreign nations.

The RAIN Alliance calls on Congress to:

- Urge the FCC to DENY the NextNav Petition for Rulemaking in WT Docket No. 24-240 in its entirety.
- Direct the FCC to seriously review and take into account the many technical studies, like that from LS telcom addressing two-way interference, and economic analysis from former FCC Commissioner and economist Harold Furchtgott-Roth, neither of which NextNav has rebutted with verified data.
- Direct the FCC to pursue GPS resiliency solutions through WT Docket No. 25-110 in a technology-neutral manner that does not foreclose RAIN RFID and the broad ecosystem of unlicensed users in the lower 900MHz spectrum band (902–928 MHz).
- Recognize the national competitiveness stakes: U.S. leadership in UHF RFID technology is a strategic asset. Granting NextNav's petition would not strengthen that asset – it would forfeit it to Chinese competitors advancing an alternative standard in international bodies today.

The RAIN Alliance welcomes the opportunity to support Congress on this important spectrum policy matter. We would be pleased to provide the Committee with additional information, technical background, briefings on RAIN RFID technology and its applications across the American economy, and/or the specific concerns raised by the NextNav Petition pending before the Federal Communications Commission. We appreciate the Committee's attention to this matter and remain committed to working constructively with Congress and the FCC toward spectrum policies that serve the broadest possible public interest.

Respectfully submitted,

/s/ Aileen Ryan

Aileen Ryan
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Wakefield MA, 01880
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www.therainalliance.org

The Honorable Richard Hudson
Chairman

The Honorable Doris Matsui
Ranking Member

Subcommittee on Communications and Technology
Committee on Energy and Commerce
U.S. House of Representatives
2125 Rayburn House Office Building
Washington, D.C. 20515

Dear Chairman Hudson, Ranking Member Matsui and Subcommittee Members,

Thank you for holding the hearing titled, "Where Are We?: Examining Positioning, Navigation, and Timing Capabilities in the United States." I applaud the subcommittee's leadership in highlighting the critical importance of national PNT resilience.

As Congress examines GPS alternatives and backup systems, it is paramount that any comprehensive PNT solution includes robust, indoor 3D location capabilities. For first responders and 911 callers, satellite-based GPS routinely fails inside multi-story structures. Having the ability to pinpoint exact horizontal and vertical locations under extreme conditions is a matter of life and death.

To provide further context on public safety's urgent needs, I have attached a recent joint letter submitted to federal administration leadership and the FCC regarding the advancement of ground-based 3D location technologies. I respectfully request that this letter be included in the official hearing record.

Thank you again for your dedication to this vital national security and public safety issue.

Sincerely,

Joseph Finn
Boston Fire Commissioner / Chief of Department (Ret.)
Boston (MA) Fire Department

June 2, 2026

The Honorable Russell Vought
Director
White House Office of Management and Budget

The Honorable Howard Lutnick
Secretary of Commerce
U.S. Department of Commerce

The Honorable Pete Hegseth
Secretary of War
U.S. Department of War

The Honorable Sean Duffy
Secretary of Transportation
U.S. Department of Transportation

The Honorable Brendan Carr
Chairman
Federal Communications Commission

The Honorable Arielle Roth
Assistant Secretary of Commerce for Communications and Information Administrator
National Telecommunications and Information Administration

Dear Federal Stakeholders,

The undersigned public safety leaders urge the Trump Administration and the Federal Communications Commission (FCC) to move forward as swiftly as possible to advance the FCC's Notice of Proposed Rulemaking (NPRM) currently undergoing interagency review to promote the development of positioning, navigation, and timing (PNT) technologies and solutions, including ground-based solutions designed to improve 3-dimensional (horizontal and vertical) location accuracy and capabilities for 911 callers and first responders. Improved 3D location accuracy will save lives of first responders and Americans they serve.

Every day, first responders operate in environments where visibility is limited, communications are compromised, and building conditions rapidly deteriorate. Current satellite-based GPS technology cannot reliably locate 911 callers and responders inside buildings or determine their vertical position within multi-story structures. Additionally, current GPS technology is subject to natural and nefarious interference and America can no longer rely on a single point of failure. For first responders and 911 callers, the need for reliable indoor 3D location capability has become even more critical.

The single most dangerous scenario in public safety is when a first responder becomes lost, disoriented, or trapped inside a structure. Without accurate and reliable 3D visibility, Command faces immense stress and confusion, forced to deploy rescue and Rapid Intervention Teams based on guesswork rather than actionable data.

In the moments that dictate life or death, we currently lack a dependable, resilient system to track our personnel inside multi-story buildings. Implementing dedicated, ground-based 3D location technology directly affords trapped civilians and responders the ability for survival. Pinpointing an exact horizontal and vertical location instantly clears the fog of the response, dramatically accelerates search and rescue operations, and ensures we can bring both the public and our own people home safely.

The need is urgent to move forward with the FCC's NPRM to enable PNT technologies and solutions well-suited for 3D indoor location.

Thank you for your leadership, and we appreciate your attention to this critical issue.

Respectfully,

Mark Antozzeski
Fire Chief
Bensalem Township (PA) Fire Department

Jacob King
Fire Chief
Springfield (OH) Fire Rescue Division

Peter Burke
Fire Chief
Hyannis (MA) Fire Department

Jeremy Knoll, Bureau Manager
Statewide Interoperability Coordinator
Wireless Systems Bureau
Arizona Department of Public Safety

Martin Dyer
Fire Chief
City of Worcester (MA) Fire Department

Brian F. Nardelli
Chief of Department
Brockton (MA) Fire Department

Joseph Finn
Boston Fire Commissioner / Chief of Department (Ret.)
Boston (MA) Fire Department

Keith Stark
Fire Chief (Ret.)
Weymouth (MA) Fire Department
Past Director, New England Division (IAFC)

Billy Harrington
President, Fairfax County Professional Firefighters and
Paramedics, Dispatchers, Local 2068
Fairfax County (VA) Fire & Rescue Department

Charles Tice
Lead Radio Communication Specialist
Texas A&M Forest Service

Michael Kelleher
Fire Chief
Foxborough (MA) Fire & Rescue



June 2, 2026

The Honorable Brett Guthrie
Chairman, Committee on Energy and Commerce
United States House of Representatives
Washington, DC 20515

The Honorable Frank Pallone, Jr.
Ranking Member, Committee on Energy and Commerce
United States House of Representatives
Washington, DC 20515

The Honorable Richard Hudson
Chairman, Communications and Technology Subcommittee
United States House of Representatives
Washington, DC 20515

The Honorable Doris Matsui
Ranking Member, Communications and Technology Subcommittee
United States House of Representatives
Washington, DC 20515

Dear Chairman Guthrie, Ranking Member Pallone, Chairman Hudson, and Ranking Member Matsui:

On behalf of PrePass Safety Alliance, thank you for your continued leadership on spectrum policy, public safety communications, transportation technology, and the reliability of critical infrastructure systems that Americans depend on every day.

PrePass Safety Alliance is a nonprofit public-private partnership of state agencies and trucking industry leaders dedicated to improving highway safety, commercial vehicle enforcement, freight mobility, and transportation efficiency.¹ Through the PrePass program, we provide the RFID infrastructure for our state partners at no cost and work with state enforcement agencies and the motor carrier industry to electronically screen qualified commercial motor vehicles and enabling safe, compliant fleets to bypass weigh stations where appropriate. PrePass also supports commercial vehicle tolling services that help fleets manage toll transactions across toll roads, bridges, and tunnels. Together, these services help enforcement agencies focus limited roadside inspection resources on vehicles and carriers that warrant greater attention, while reducing congestion, idling, delay, and unnecessary stops for safe carriers.

¹ PrePass Safety Alliance, "About the Alliance," accessed June 1, 2026, <https://prepassalliance.org/about/>



We write to express our deep opposition to any effort to reconfigure the 902–928 MHz spectrum band, commonly referred to as the Lower 900 MHz Band, in a manner that would jeopardize existing highway safety, weigh station bypass, electronic tolling, and transportation operations for commercial motor carriers. Specifically, we oppose the petition² filed by NextNav Inc. at the Federal Communications Commission seeking to reorganize the Lower 900 MHz Band to support a terrestrial positioning, navigation, and timing network and related 5G broadband operations.

PrePass Safety Alliance recognizes the national importance of resilient positioning, navigation, and timing capabilities. GPS vulnerabilities are real, and the United States should continue evaluating complementary and backup PNT solutions through a coordinated whole-of-government approach.

That work is already underway across the federal government: the U.S. Department of Transportation is assessing more than a dozen complementary PNT services;³ the Federal Communications Commission has developed a record on technological solutions and alternatives;⁴ and the National Telecommunications and Information Administration has identified approximately 50 potential technologies or solutions that could complement GPS.⁵ However, resilient PNT policy should not come at the expense of proven, operational safety systems that already support commercial vehicle enforcement, tolling, freight movement, and roadway safety across the country.

The Lower 900 MHz Band is not vacant spectrum. It is a heavily relied-upon band that supports transportation safety, industrial systems, utilities, logistics, agriculture, building systems, security, and other public-interest operations. The FCC has recognized this broad incumbent use, including federal and non-federal operations, Part 15 unlicensed devices, amateur radio operators, Location and Monitoring Service licensees, and approximately 1,500 active non-M-LMS licensees.⁶

² Federal Communications Commission, Public Notice, *NextNav Petition for Rulemaking, Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz)*, WT Docket No. 24-240, released Aug. 6, 2024, 2 https://docs.fcc.gov/public/attachments/DA-24-776A1_Rcd.pdf.

³ U.S. Department of Transportation, “Department of Transportation Awards \$7 Million for Complementary Positioning, Navigation and Timing Technologies,” press release, July 3, 2024, <https://www.transportation.gov/briefing-room/departments-transportation-awards-7-million-complementary-positioning-navigation-and>; SAM.gov, “Complementary Positioning, Navigation, and Timing Services Rapid Phase II,” award notice, <https://sam.gov/opp/396f1f1e901a4155ace2263e3c70a588/view>.

⁴ Federal Communications Commission, *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, WT Docket No. 25-110, FCC 25-20, released March 28, 2025.

⁵ National Telecommunications and Information Administration, ex parte letter to the Federal Communications Commission, *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, WT Docket No. 25-110, May 27, 2025, <https://www.fcc.gov/ecfs/document/1052783551421/1>.

⁶ Ibid.



For the commercial vehicle safety community, the Lower 900 MHz Band is especially important because it supports RFID transponder-based technologies used in weigh station bypass and tolling. PrePass transponders communicate with roadside infrastructure to identify qualified commercial motor vehicles and support safe, efficient, and lawful bypass decisions. These systems are not theoretical. They are deployed at scale, integrated into state enforcement operations, and relied upon daily by motor carriers, state DOT and enforcement agencies, and toll authorities.⁷

Since the program began, PrePass has supported 1.6 billion bypasses, generated an estimated \$12 billion in operational cost savings, saved 136 million driver hours, saved 584 million gallons of fuel, and avoided approximately 1 million metric tons of CO₂e emissions.⁸ PrePass Safety Alliance has also invested more than \$1.3 billion nationally, at no cost to taxpayers, to deploy services that enable weigh station infrastructure and safety technology nationwide. These outcomes are the result of decades of collaboration between the public and private sectors and reflect a spectrum band plan that has successfully enabled transportation safety technology to operate reliably at scale.

Disruption to these systems would carry direct safety consequences. Weigh station bypass is not simply a convenience for motor carriers. It is a safety and enforcement tool. By enabling safe, qualified motor carriers to remain on the highway, bypass programs help enforcement agencies focus attention on higher-risk vehicles and carriers. If transponder performance is degraded, roadside communication becomes less reliable, and more compliant trucks may be unnecessarily routed into weigh stations. That increases congestion at inspection facilities, creates new traffic conflict points near entrance and exit ramps, diverts enforcement resources away from higher-priority vehicles, and undermines the efficiency of the enforcement screening model.

The same concern applies to electronic tolling. Many commercial motor carriers rely on transponders for tolling operations across toll roads, bridges, and tunnels. Interference or degraded performance could lead to inaccurate reads, missed transactions, higher administrative costs, delayed billing, customer disputes, and increased costs for carriers. Testing submitted in the FCC docket by TransCore and Kapsch underscores the need for caution, identifying potential interference risks to tags, readers, tag-to-reader handshakes, toll system performance, electronic toll collection, and commercial vehicle operations.⁹

⁷ U.S. Chamber of Commerce et al., reply comments on the NextNav petition, WT Docket No. 24-240, Sept. 20, 2024, citing PrePass Safety Alliance comments.

⁸ PrePass Safety Alliance and PrePass, *Mile Marker 2026: The National Bypass Impact Index*, 2026, released March 26, 2026.

⁹ TransCore, *E6 Reader and Tag Interference Tolerance from NextNav 5G NR Bench Test Signals*, WT Docket No. 24-240, filed March 2, 2026; Kapsch TrafficCom, *Kapsch TrafficCom Test and Coexistence Analysis of*



In an industry emerging from two years of freight declines and continued operating-cost pressure, disruptions to tolling reliability would not remain isolated; they would ultimately affect freight costs, supply chains and consumers.¹⁰

Principles

PrePass Safety Alliance respectfully urges the Committee and the Subcommittee to ensure that any consideration of the Lower 900 MHz Band is guided by the following principles:

1. **Protect existing transportation safety and tolling operations.** The FCC should not authorize any reconfiguration that would degrade or disrupt weigh station bypass, tolling, commercial vehicle screening, or other safety-relevant systems operating in the band.
2. **Require independent, transparent, real-world testing before any rulemaking proceeds.** Laboratory assumptions are insufficient. Testing should evaluate actual operational environments, including roadside infrastructure, tolling locations, transponder performance, state enforcement use cases, and the full range of incumbent systems operating in the band.
3. **Preserve enforceable interference protections for incumbent users.** Existing users should not be forced to accept harmful interference, degraded service, costly equipment replacement, or operational uncertainty as the price of a private spectrum reorganization.
4. **Reject any approach that shifts costs to public agencies, motor carriers, tolling authorities, or consumers.** If a proposed reconfiguration would require mitigation, replacement, relocation, or redesign of existing systems, those costs should not fall on the public or on industries that built reliable systems under the existing rules.
5. **Pursue resilient PNT policy through a technology-neutral, transparent, and competitive process.** The national need for GPS resilience should not be used to justify a single-company spectrum outcome that risks undermining proven systems already advancing safety, mobility, and infrastructure performance.

Kapsch NM-LMS Equipment to the NextNav Proposed Wireless Communications in the LMS Band, WT Docket No. 24-240, filed March 18, 2026.

¹⁰ American Trucking Associations, *American Trucking Trends 2025*, Aug. 28, 2025, <https://www.trucking.org/news-insights/ata-american-trucking-trends-2025>; American Trucking Associations, “Truck Freight to Bounce Back in 2025, ATA Projects,” Jan. 16, 2025, <https://www.trucking.org/news-insights/truck-freight-bounce-back-2025-ata-projects>; American Transportation Research Institute, *An Analysis of the Operational Costs of Trucking: 2025 Update*, July 2025, <https://truckingresearch.org/2025/07/an-analysis-of-the-operational-costs-of-trucking-2025-update/>.



PrePass Safety Alliance strongly supports innovation that improves transportation safety and national resilience. But innovation must be additive, not disruptive. The Lower 900 MHz Band delivers significant measurable public benefits for commercial motor vehicle highway safety, enforcement efficiency, freight movement, emissions reduction, and tolling operations. Any federal action that puts those benefits at risk would disrupt our nation's critical supply chain and be contrary to the public interest.

For these reasons, PrePass Safety Alliance respectfully urges Congress to exercise close oversight of the FCC's consideration of the NextNav petition and to ensure that any action preserves the critical transportation safety, tolling, and infrastructure systems that rely on the band today.

Thank you for your consideration of our views. We welcome the opportunity to provide additional information to the Committee and the Subcommittee on the importance of the band to commercial vehicle safety, enforcement modernization, and the efficient movement of freight across the U.S.

Sincerely,

A handwritten signature in black ink, appearing to read 'Ashley Simmons'.

Ashley Simmons
Vice President of Policy & External Affairs
PrePass Safety Alliance



Statement of the

National Retail Federation

Submitted to the

**U.S. House of Representatives Committee on Energy and Commerce
Subcommittee on Communications and Technology**

For its hearing

**Where Are We?: Examining Positioning, Navigation, and Timing Capabilities in the
United States**

June 4, 2026

Chairman Guthrie, Chairman Hudson, Ranking Member Pallone, Ranking Member Matsui, and
Members of the Committee:

The National Retail Federation (NRF) appreciates the Committee’s attention to the critical issue of strengthening America’s Positioning, Navigation, and Timing (PNT) capabilities and improving the resilience of systems that support our economy, national security, and public safety. Retailers depend on reliable PNT services through all facets of their operations from transportation and logistics networks to supply chain management and payment systems. NRF strongly supports efforts to identify and evaluate complementary technologies that can create a resilient backup to the Global Positioning System (GPS).

NRF, the world’s largest retail trade association, passionately advocates for the people, brands, policies and ideas that help retail succeed. NRF empowers the industry that powers the economy. Retail is the nation’s largest private-sector employer, contributing \$5.3 trillion to annual GDP and supporting one in four U.S. jobs — 55 million working Americans. For over a century, NRF has been a voice for every retailer and every retail job, educating, inspiring and communicating the powerful impact retail has on local communities and global economies.

As Congress considers potential PNT alternatives, however, it is essential that policymakers carefully evaluate the costs, tradeoffs, and unintended consequences associated with any proposed solution. In particular, NRF is deeply concerned with the proposal by NextNav Inc. (“NextNav”)¹ to the Federal Communications Commission that would fundamentally reconfigure the Lower 900 MHz band (902-928 MHz), a spectrum band that supports a vast ecosystem of technologies relied upon by retailers, supply chain operators, manufacturers, transportation providers, utilities, public safety entities, and consumers.

¹ NextNav Petition for Rulemaking, Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz), Public Notice, WT Docket No. 24-240 (rel. Aug. 6, 2024) (“Public Notice”). <https://www.fcc.gov/ecfs/search/docket-detail/24-240>

The FCC record demonstrates that the Lower 900 MHz band is far from underutilized. Rather, it supports millions of deployed devices and critical applications across the economy, including RFID inventory systems, asset tracking technologies, warehouse automation platforms, electronic article surveillance systems, smart sensors, logistics monitoring equipment, and store security systems that retailers use every day to improve efficiency, reduce shrink, and keep costs down for consumers.² Numerous stakeholders have documented extensive use of the band and raised concerns that NextNav's proposal would create significant interference risks and spectrum congestion for incumbent users. Commenters ranging from the RAIN RFID community and security industry stakeholders to utilities, transportation providers, technology companies, and consumer groups have warned that introducing high-power terrestrial operations into a band designed around low-power coexistence could disrupt existing operations and degrade performance for incumbent systems.³

For retailers, the consequences would be particularly significant. RFID technology has become a foundational tool for modern inventory management, omnichannel fulfillment, loss prevention, and supply chain visibility.⁴ Retailers have invested billions of dollars over many years to deploy RFID systems that operate within the current spectrum framework. These technologies enable more accurate inventory management, reduce waste, improve product availability, and support the seamless shopping experiences consumers increasingly expect. Likewise, many retail facilities rely on wireless security systems, sensors, alarms, and monitoring equipment to ensure public safety that utilize the Lower 900 MHz band because of its propagation characteristics and reliability.⁵

NextNav's proposal would compress existing users into a substantially smaller portion of the band while simultaneously introducing high-power licensed operations into spectrum that has historically functioned as a shared environment. FCC filings from numerous technical stakeholders have entered studies into the FCC record that challenge NextNav's coexistence analyses and show that the company's studies underestimate real-world interference impacts and fail to account for practical deployment conditions.⁶ Multiple commenters have concluded that harmful interference, increased congestion, and degraded system performance are likely outcomes if the proposal moves forward.⁷ One of the more challenging aspects of the NextNav proposal is the request to rewrite the accepted rules of the band, which would require the takedown of any technology that would interfere with a proposed new NextNav band. This is not how the system currently works today. If such new rules would go forward, this would significantly impact any use of the spectrum since we know interference would occur.

² NextNav Petition Coalition Reply Comments, WT Docket No. 24-240 (Sept. 20, 2024); Comments of Enterprise Wireless Alliance, WT Docket No. 24-240, RM-11989 (Sept. 5, 2024).

³ Consumer Technology Association, Comments, WT Docket No. 24-240 (Sept. 5, 2024); Comments in Opposition of Open Technology Institute, Public Knowledge, Consumer Reports, Next Century Cities, Schools, Health & Libraries Broadband Coalition, and Digital Progress Institute, WT Docket No. 24-240 (Sept. 5, 2024).

⁴ RAIN Alliance, Update on NextNav Petition for Rule Change (Mar. 13, 2025); Comments of AIM, Inc., WT Docket No. 24-240.

⁵ Security Industry Association, Protect the Lower 900 MHz Band (2025); Comments of the Security Industry Association, WT Docket No. 24-240.

⁶ Comments of Enterprise Wireless Alliance, WT Docket No. 24-240; Security Industry Association Reply Comments, WT Docket No. 24-240; LoRa Alliance Comments, WT Docket No. 24-240.

⁷ NextNav Petition Coalition Reply Comments, WT Docket No. 24-240.

Beyond the technical concerns, the economic implications are staggering. Industry analyses submitted into the FCC record estimate that reconfiguring the band could impose tens of billions of dollars in costs on incumbent users through equipment replacement, retuning, infrastructure upgrades, and operational disruptions.⁸ Retailers would be forced to evaluate replacement or modification of RFID readers, tags, sensors, inventory management systems, warehouse equipment, and security technologies deployed across stores, distribution centers, and supply chains nationwide.⁹ Some NRF members note that the cost of an RFID tag today is \$.02. If the NextNav proposal were to go into effect, the cost would increase 10-fold, resulting in billions of dollars of increased replacement costs. These costs would ultimately ripple throughout the economy.

Such a proposal comes at an especially difficult time. Retailers continue to face significant pressure from rising operating costs, persistent supply chain challenges, organized retail crime, and ongoing efforts to keep products affordable for American families. Imposing billions of dollars in unnecessary transition costs on businesses that rely on the Lower 900 MHz band would inevitably increase costs throughout the supply chain and place additional upward pressure on consumer prices at a time when affordability remains a top concern for households across the country.¹⁰

Importantly, the proposal's purported PNT benefits do not appear commensurate with the disruption it would cause. By NextNav's own representations, only a small portion of the 15 MHz nationwide license it seeks would be dedicated to providing PNT functionality.¹¹ Public filings and analyses of the proposal indicate that the overwhelming majority of the spectrum would instead be available for commercial wireless broadband use and leasing arrangements with mobile network operators.¹² In other words, the proposal would not simply create a GPS backup system; it would fundamentally restructure a shared spectrum ecosystem to support broader commercial wireless operations that extend well beyond PNT services.¹³ In addition, this would essentially be a regulation of an otherwise open spectrum market. This goes against the administration's own goals of deregulation.

The Committee's hearing appropriately highlights the importance of evaluating alternatives to GPS. NRF supports continued exploration of technology-neutral approaches that can enhance resilience without disrupting existing spectrum ecosystems or imposing unnecessary costs or jeopardizing public safety.¹⁴ The United States should pursue solutions that strengthen national resilience (such as the other pilot programs currently being tested through the

⁸ NextNav Petition Coalition Reply Comments, WT Docket No. 24-240, citing estimated device replacement costs of approximately \$27–33 billion.

⁹ RAIN Alliance, WT Docket No. 24-240; AIM, Inc., WT Docket No. 24-240.

¹⁰ NextNav Petition Coalition Reply Comments, WT Docket No. 24-240.

¹¹ Broadband Breakfast, FCC Flooded with Opposition to NextNav's GPS Backup Proposal (Apr. 2025).

¹² NextNav, Lays Out New Vision (Investor Presentation).

¹³ NextNav Inc., Petition for Rulemaking, WT Docket No. 24-240.

¹⁴ Federal Communications Commission, Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions, Notice of Inquiry, WT Docket No. 25-110 (Mar. 27, 2025).

Department of Transportation, none of which ask to reconfigure the lower 900 MHz band) while preserving the critical technologies and infrastructure that Americans already rely upon.

We very much appreciate the Committee's continued attention to these issues and its ongoing oversight of both federal PNT initiatives and proposals that could significantly impact incumbent spectrum users. We respectfully urge the Committee to continue exercising its oversight authorities to ensure that any future PNT policies are grounded in sound engineering, rigorous technical analysis, and a full understanding of the consequences for American businesses and consumers.

Thank you for the opportunity to submit this statement for the record.



Amtech Technology Center
8600 Jefferson Street NE
Albuquerque, New Mexico 87113
505.856.8000 tel 505.857.0715 fax

2 March 2026
Marlene H. Dortch, Secretary
Federal Communications Commission
45 L Street NE
Washington, DC 20554

Re: Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking (WT Docket No 24-240), Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions (WT Docket No. 25-110)

Dear Ms. Dortch:

TransCore, being a leading manufacturer and system integrator providing RF identification equipment and systems to the transportation industries that utilize the LN Radio Service, encloses a bench test report addressing the impact of the NextNav Proposed 5G-LMS expansion of the LS Radio Service allocations with significant rule changes to create a 5G "Lower 900 MHz" service.

The NextNav petition requested a change to the multilateration rules as implemented, allowing more power, and moving their sub-band down into the allocated band, with no guard band for RFID based systems, impacting existing products and many licensed sites.

Current tolling systems utilize 902-904 and 909.75–921.75 MHz LN with multiprotocol readers/antenna placed across multi-lanes and near each other. High read reliability (99.98% or better) is operationally required, and to achieve this careful frequency, power levels, interference and timing must be optimized.

Testing

TransCore conducted testing to assess how the proposed NextNav 5G PNT system, operating in an expanded adjacent spectrum, may interfere with readers and tags used in national interoperable tolling systems. The evaluation covered the National Interoperability protocols of TDM, SeGo, and 6C on both tags and readers. Testing followed established tolling industry procedures developed in coordination with E-ZPass® Interagency Group (IAG) and International Bridge, Tunnel and Turnpike Association (IBTTA) representatives.

Both lab and lane results show that 5G signals from the base stations and handsets can significantly degrade tolling system performance, with the degree of degradation, varying per protocol. Interference was observed in all modes tested and included impacts to the tag, reader, and the system level tag to reader handshakes. These effects can reduce or prevent tag reading entirely.

In addition, the proposed 5G signals from the base station extend to multi-mile distances for some protocols, while handset interference was measurable at tens of feet and may affect tags inside vehicles and readers over the roadway. The severity of interference is influenced by typical system gains and losses, reflections from vehicles and roadside infrastructure, as well as the variation in peak to average 5G signals. Even small bit errors can disrupt tag-to-reader communication because some protocols rely on single frame responses. The interference levels vary across protocols, reader types, and environmental conditions.

Conclusions

Test result conclusions, based upon the testing methodology and procedures developed in coordination with the IAG and IBTTA representatives, are the following:

- Change in bandwidth will impact reader software/firmware
- Change in bandwidth may impact reader hardware and/or require additional hardware in the plaza incurred at the plaza
- Reduced life in battery powered tags from false triggering

- Distance required to mitigate possible interference in the system is many meters to kilometers depending upon protocols and specific situations

Based upon the data provided in this test report and the multitude of other responses to Docket No. 24-240, the FCC should DENY the NextNav Petition.

Respectfully submitted,

John Mike, General Manager

TransCore

NEXTNAV 5G NR INTERFERENCE TOLERANCE TESTING TO E6 & OTHER READERS & TAGS

BENCH TEST REPORT

3-2-2026

PRODUCT: TransCore E6 READER & Tri-Protocol Tags, IAG
TDM, 6C, SeGo

DOCUMENT NUMBER: _____

REVISION: C3

TransCore, 8600 Jefferson NE, Albuquerque, NM 87113

DOCUMENT REVISION CONTROL

Applicability: Test Report

Revision:

Version Date	Revision	Changes	Editor
Date of Revision	Revision ID	Description of changes	Initials of Editor
11-26-2025	A	Original Issue	RWD
1-27-2026	B	Updates with 5G model for reader paths	RWD
2-3-2026	C	Final Updates	RWD

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NEXTRAV 5G NR INTERFERENCE TOLERANCE TESTING TO E6 & OTHER READERS & TAGS

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1. OVERVIEW AND FINDINGS

Testing was conducted by TransCore to evaluate the tolerance to interference by readers and tags from a proposed NextNav PNT 5G cellular system operating in expanded adjacent sub-band frequencies. The National Toll Interoperability protocols of TDM, SeGo, 6C were tested on the E6 reader from TransCore using a variety of tags of these protocols from various manufacturers. Testing also included other vendor's readers as reported in an appendix. At the very end of the report conclusions are provided

Testing was based upon the tolling test plan prepared jointly by several AVI tag and reader manufacturers coordinating with the E-ZPass® and IBTTA industry technical representatives.

Data is presented in the RF level in dBm at the reader and extrapolated to modeled distance to not exceed those RF levels at the reader under calculated conditions. Additional path loss calculations used 5G Path Loss modeling, typically for line of sight, but for the extended distances of IAG TDM reader interference, the 5G Rural Non-Line-of-Sight distance is also shown.

Interference was seen that can significantly reduce the handshakes leading to incorrect tag to lane voting, or misses (non-reads) in tolling from this benchtop investigation.

Handshake reduction and misses were found in bench top testing in all modes of interference,

- 5G Base Station to Tag
- 5G User equipment Handset cellphone to Tag
- 5G Base Station to Reader
- 5G User equipment Handset cellphone to Reader

The magnitude of interference is shown to extend to miles for some cases from 5G base stations, and to dozens of feet from handsets passing under reader antennas. Even tags are impacted inside the vehicle by the 5G handset during those transmissions.

The data is recorded in dBm at the receiver for this bench testing and while there are other gains and losses in real installations, they often nearly cancel each other out:

- The antenna gain is typically 12 to 14 dBi depending upon the antenna model
- Cable losses from reader to antenna are typically limited to 3 dB or less
- Antenna side lobes theoretically reduce the signal 10 to 20 dB, but
 - o Reflections will sometimes be present from one or more vehicles, buildings, or other metallic surfaces in the area to enhance signal level up into the receive antenna by 5 to 10 dB or even more.
 - o Reflections not only enhance signals but in multipathing, they may combine for null zones reducing the signal levels briefly.

It is noted that peak to average interference levels of 5G vary by 10.77 dB, with those peaks potentially changing the data of tag reading or writing easily, and a single bit error results in data corruption, handshake reduction, and potentially tag misses since some tags read with only one frame of data (a handshake or seen count).

Testing is for co-polarization to understand these cases, but clearly interference is often reflected resulting in various resulting polarizations in the metallic moving vehicle cases present. While cross polarization can result, reducing interference impacts, the 5G use of +/- 45 slant cross polarization limits signal reduction to 3 dB maximum. Also, there are many other effects simultaneously present such as reflected enhancements.

Furthermore, interference is still seen for a re-designed frequency offset of IAG TDM protocol tags and readers to the proposed new band center. Frequencies that were further away from the interference in MHz showed slightly more tolerance, but the reduction in susceptibility was minimal. New Product design of TDM using the center of the new band appears to result in only a couple of dB difference, not enough in many close-in cases to prevent significant interference if avoiding base station interference. Of course, avoiding base station transmissions means the tag is now using a frequency closer to the user equipment cellphone handset. Handset interference to the reader resulted in 16 dB more interference, when the TDM frequency is moved lower to the proposed band center, meaning re-centering the TDM frequency may not provide needed improvement in reader interference rejection.

This report does not consider reader or transponder interference to the NextNav proposed 5G service handsets or base stations.

Initial findings are presented in this report, and follow-on investigations will continue.

NEXTRAV 5G NR INTERFERENCE TOLERANCE TESTING TO E6 & OTHER READERS & TAGS

The distance calculations provided are based on testing and path loss modeling, with actual losses varying with local conditions, often line of sight.

1.1 NextNav Proposal to Deploy 5G PNT & Cellular in bands used by tolling

NextNav has petitioned the FCC under proceeding 24-240, with additional FCC considerations of PNT (Position, Navigation and Timing) complementary and alternative technologies to GPS under proceeding 25-110. NextNav proposes using 5G NR (New Radio) waveforms as currently used in cellular applications over the following frequency ranges.

- Base Stations 918 to 928 MHz
- Upgraded Cellphone Handheld and other user equipment 902 to 907 MHz

NextNav is requesting rules that would conform to current cellular regulations under the June 2024 supplemental filing:

- Base Station antenna ERP allowed up to 1,000 watts/MHz in urban areas and 2,000 watts/MHz in rural installations, which means up to 10,000 watts in urban and 20,000 watts in rural over the 10 MHz band proposed
- Handsets up to 3 watts ERP

The NextNav petition would remove multilateration from the Location and Monitoring rules as implemented to date by Progeny and licensed by the FCC under the LS Radio Service. Instead, a new 5G service for wireless communications supporting position, navigation, and timing, plus leased data and voice is proposed.

1.2 Tolling Use of the band

Tolling readers, such as the E6 readers tested, are installed in multiple lanes of a tolling zone on open road tolling (ORT), as licensed by the FCC in the LN Radio Service. Installed readers/antennas are on lane centers and stripes with as little as 6-foot separation with adjacent readers/antennas using three separate channels with bandwidth to cover the current 12 MHz allocation of 909.75 to 921.75 MHz such that the full sub-band is utilized. The upper 2 MHz has been successfully shared in hundreds of installations across the country since multilateration sites have been significantly separated from tolling sites and the duty cycle from a single multilateration site has been much lower than proposed for the 5G PNT cellular expansion, with a shifting and reduction in tolling bandwidth.

These readers are tri-protocol, interrogating the IAG TDM, SeGo, and 6C protocols rapidly in successive time segments. Tolling installations expect that any vehicle may have 1, 2, or all 3 protocols in use by tags in each vehicle passing at high vehicle speeds.

Generally, tag reading by tolling agencies is expected to be successful for 99.98% of the vehicles passing without misses or errors in the data as introduced by outside interference or other reasons.

While some tolling agencies rely on tag writing to have the tag carry data such as HOV enforcement switch status, time and/or location of last read to the next reader, the testing so far has concentrated in tag reading. Typically, the tag write-operation impairment is found to be about 2 dB more sensitive to outside interference for the TDM protocol.

1.3 Other uses of AVI readers in the band

This analysis concentrates on the latest installations that use the current 909.75 to 921.75 12 MHz sub-band for the LN Radio Service. Most such installations have multiple readers in proximity using frequencies in order across the whole 12 MHz sub-band.

Earlier installations or other applications are often still using 902 to 904 MHz portions in addition to the above sub-band, with examples being airports, rail, parking lot or facility access control.

It is important to recognize that backscatter tags have been designed to work from 902-921.75 MHz for licensed US installations, and some products extend the frequency range higher to cover the Part 15 unlicensed frequency hopping or lower frequencies to cover foreign UHF bands.

1.4 Progeny agreement with E-ZPass on TDM Standoff Distances 2015

During the 2011 to 2015 period the FCC allocation of multilateration radio service use of the sub-band adjacent to tolling readers was evaluated and tested closely for the Progeny use of 30 Watts peak ERP (44.77 dBm) impact to the tolling IAG TDM protocol. E-ZPass and Mark IV (now Kapsch) are reported (in recent FCC filings) to have come to an agreement with Progeny that a one-mile standoff distance or more along the road in the direction of toll reader antenna pointing, with reduction for off-axis conditions, would not be of concern for one of the proposed (at that time) modes of Progeny operation, but closer distances would require site specific evaluation.

Progeny Multilateration uses portions of the 919.75 to 928 MHz sub-band.

It is worth noting that the co-existence separation distances determined for Progeny were based on measured results in live toll site (actual transponders on vehicles) and margin added to address variation in transponder product, including temperature and life.

For this report 5G path loss models are used to estimate required distances to prevent interference.

It should be noted that the Progeny use of 100 milliseconds per site every second for a 10 % duty cycle for the closest site could blank out a high-speed vehicle, hence scaling to higher NextNav signals and duty cycles should be considered in an initial gate for analysis.

Besides power increase, the NextNav proposal also includes changes in the timing of signals with a higher duty cycle, shifted frequencies, and zero guard band for today's tri-protocol usage as compared to the Progeny agreement.

This report's bench testing below shows potentially different levels of RF susceptibility for 5G signals depending upon reader, frequencies, protocols and of course path losses of installations.

1.5 Bench Testing

Bench Testing is an initial step in an interference susceptibility testing process to determine levels that would inform future possible outdoor test lane or installed tolling conditions where additional variations in conditions would occur due to the pointing, path losses, local reflections and shielding of the reader antenna or tag.

The bench testing simplifies the environment allowing better comparisons and understanding of the basics. The goal of bench testing is to determine the RF signal levels where interference starts or is complete, along with the interference to signal I/S tolerance characterization.

TransCore used the "Lab_Interference_Test_250206_Final.doc" test plan as prepared by a group of E-ZPass manufacturers and tolling agency technical representatives in February of 2025.

Bench testing can then be used to obtain a first order estimation of separation distance required between 5G NR and tolling readers and tags for the different contributions of interference to tag and separately to the reader.

Measurements are made on a single protocol and single device (tag or reader) at a time, although actual installations are more complicated with multiple readers, tags, protocols, and installation influences.

While this initial round of testing involves IAG TDM, SeGo and 6C protocols, there are additional protocols used in some tolling, truck weigh station bypass, rail, and access control installations:

- ASTM v6 is used for Truck Weigh Station Bypass where the tag sensitivity is about -19 dB more sensitive than the IAG TDM protocol. Thus, interference could cover miles with 19 dB more protection required for ASTM v6 TDMA and may extend to 10's of miles if antenna boresights were aligned.
- Railroads use the ATA protocol S-918 Standard of the AAR with signaling characteristics that are significantly different than the protocols being tested.
- The Title 21 California tolling standard uses backscatter tags communication that is being phased out in January 1, 2027, and therefore not included in this initial study

1.5.1 Reader test

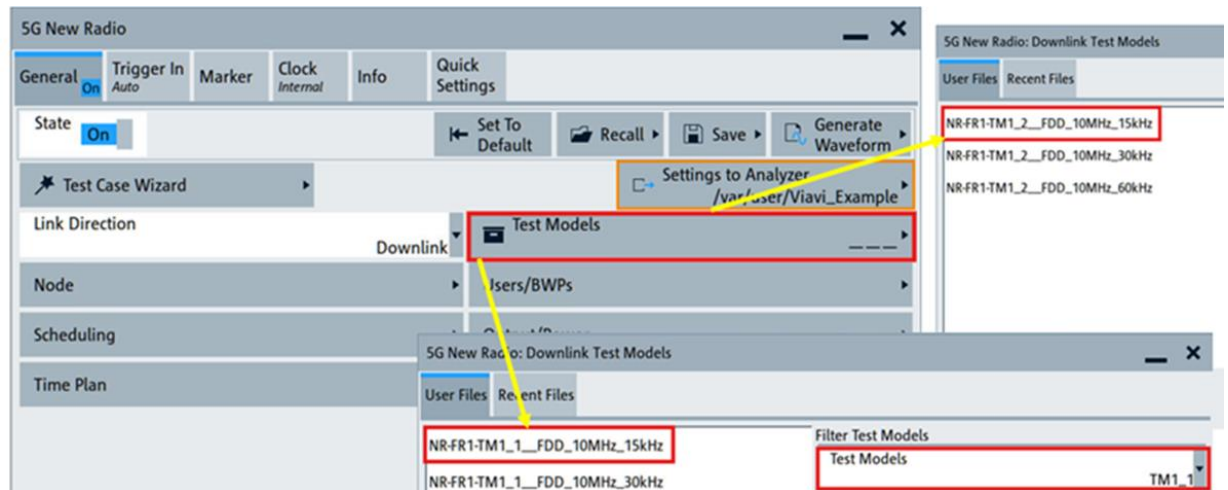
TransCore set up the E6 reader to communicate with a tag of a specific protocol in a shielded "Tag in Box" TIB with circulators, variable attenuators fixed attenuator and other cabling connected to and protecting a signal generator outputting the 5G NR Release 15 and 16 waveforms, as defined with the following for the base station case:

- Rohde and Schwarz SWM200A signal generator with the required 5G NR options of K520, K61, K144 K148.
- 3GPP TS 38.141-1
- 10 MHz width for the proposed 918 to 928 MHz base station
 - o With an added step of also testing interference tolerance if a new TDM product were tuned to the middle of the resulting tolling allocation at 912.5 MHz by moving the 5G base station to 921.25 to 931.25 MHz
- 15 KHz sub-carrier spacing (SCS) with the smallest guard band of 250 kHz
- NRFR1-TM1.1 (FDD_10MHz_15kHz) Section 4.9.2.2.1 with primary usage of PDSCH and all resource blocks at same power level

Additionally, Handset interference waveforms were defined as

- 3GPP TS 38.141-1
- Fixed Reference Channel G-FR1-A1-1 for the 5 MHz 902 to 907 MHz band with 15 kHz subcarriers, Appendix A-1 with PUSCH (physical uplink shared channel)

As an example, setup of the analyzer has many inputs including those as shown in this partial screen shot



Setup involved determining the minimum RF level wake-up and setting the reader downlink power at 3 dB signal margin above minimum Wake-Up to read tags. This 3 dB signal margin is used to determine the basis for the I/S interference to signal level. Additional signal margins of 6 and 9 dB were included for reader testing.

Then with the interference starting at a low value, the generator interference signal levels are increased to find the point of

Handshakes at 90% of baseline

Handshakes at 50% of baseline, and

Handshakes at 5% or less including full miss.

Each of these RF levels of interference were determined and recorded.

1.5.2 Tag Test – National Interoperability Protocols

The Tag testing included placing the tag on glass in an anechoic chamber with an antenna having the combined reader and 5G Interference, as driven by a variety of components including:

- Circulators
- Loads
- Fixed and Variable Attenuators
- PIN Attenuator switches for uplink blanking to provide only reader downlink to tag susceptibility measurements
- Amplifier and several spectrum analyzers monitoring signals from the reader, tag (zero span response observation), and 5G interference

22 Tag models tested included identified with number from tables

- 1. TransCore NP2, a Multi-Protocol Tag having all three protocols separately tested
- 2. Kapsch G4, TDM
- 3. Kapsch G5, TDM
- 4 TransCore JED III, TDM
- 5. TransCore JED II, TDM

6C Tags used in NextNav Testing	Vendor ID	Name	Model ID #	Model Name
1. TransCore NP2 - UNI and SunPass Pro with 6C, SeGo, TDM protocols	80B	EM	44	EM4325 V21
6 GeauxPass 6C with NXP chip	006	NXP	80B	G2 iM+
7. FastTrak Switchable HOV/SOV A-H 9	80B	Alien	110	Higgs 9
8. Express Sticker Tag Alien Higgs3	003	Alien	412	Higgs 3
9. Impinj Monza 4QT	801	Impinj	105	Monza 4QT
10. Impinj Monza R6	801	Impinj	160	Monza R6
11. Imp Monza 5	801	Impinj	130	Monza 5
12. Tag I Impinj M830	801	Impinj	1B0	M830
13. Tag D Impinj M730	801	Impinj	191	M730
14. AD-663U7XM NXPXTID	806	NXPXTID	F12	Ucode 7m
15. AD-324U8 ETSI NXPXTID	806	NXPXTID	894	Ucode 8
16. AD-383U7 NXPXTID	806	NXPXTID	890	Ucode 7m
17. eGo Plus Dual 6C Sticker Tag	80B	EM	110	EM4425
18. GoAP3 +6C with 6C, SeGo, and TDM Protocols	80B	EM	044	EM4325 V21

-
- 19. SeGo MicroMini Sticker Tag
- 20. SeGo MicroMini TX Tag
- 21. KTag SeGo
- 22. SeGo MicroMini

This wide variety of tag models are not uniformly used in tolling since tolling agencies tend to order certain tags at various times. However, with interoperability all these tags can pass through any toll system and need to be supported.

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Also, when tags are applied to vehicles, differences of plus or minus 1 to 3 dB are found in outdoor testing just from specific placement location or vehicle type, even when manufacturer mounting instructions are followed.

1.5.3 Summary of Test Results

Results are reported as 5G interference signal levels for 90%, 50%, and 5% (or less including miss) of baseline Handshakes for each tag and test configuration including frequency offset variations.

1.5.4 Distance away

The report also includes a summary of modeled Base Station and Handset Power level to distance away for various dBm threshold values, test cases, protocols and tags as found in testing. The modeled line of sight distances is shown and where appropriate non-line-of-sight modeling is included. The following 3GPP path loss models are included for the signal protection levels found necessary in bench testing from the 5G Base Stations proposed by NextNav:

- Urban Macro 3D-Uma Line of Sight, Base at 25 meters
- Rural Macro 3D-RMa Line of Sight, Base at 35 meters
 - o Additionally, for IAG TDM protocol, Rural Macro 3D-RMa non-LOS was included due to the large distances, exceeding the other path loss models maximum of 5,000 meters.
- Urban Micro 3D-Umi Line of Sight, Base at 25 meters

For the in-vehicle user handset cases, the 5G path model was

- Indoor Hotspot 3D-InH Line of Sight

1.6 Definitions, Acronyms, Abbreviations

The following terms may have been used in this document

The terms transponder, tag and OBU are used interchangeably within this document. All three terms refer to the vehicle mounted mobile device used to communicate with the fixed roadside reader for AVI purposes.

3GPP	3rd Generation Partnership Project collaboration of standard development organizations
5G	5 th , newest cellular standard also referred to as 5G NR for new radio
6C	ISO-18000-6C now updated to ISO 18000-63 standard as defined by the Toll Operations Committee known as 6C TOC
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
AVI	Automatic Vehicle Identification
CPU	Central Processing Unit
dBm	Decibels with respect to one milliwatt (and – indicates negative, reductions below zero)
E6	Encompass 6 Reader from TransCore
ERP	Effective Radiated Power, RF power as transmitted from an antenna in Watts or +dBm
ETC	Electronic Toll Collection
FCC	Federal Communications Commission
IAG	Interagency Group that started off with the TDM Time Division Protocol
IBTTA	International Bridge, Tunnel and Turnpike Association
IEEE	Institute of Electrical & Electronics Engineers, Inc.
ISO	International Standards Organization
LC	Lane Controller
LN	FCC radio service for Land Navigation, non-multilateration used by tolling readers
LS	The multilateration radio service as licensed by Progeny- NextNav is seeking revisions
NIOP	North American Toll Interoperability Program
NR	New Radio the 5 th generation of cellular 5G NR, replacing 4 th Gen LTE
OBU	On-Board Unit
ORT	Open Road Toll
PDSCH	Physical Downlink Shared Channel
PNT	Position Navigation & Timing services NextNav is proposing in addition to 5G leasing
PSM	Power Supply Module
PUSCH	Physical Uplink Shared Channel
RF	Radio Frequency
SeGo	Super eGo®
STD	Standard
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TDM	Time Division Multiplex –RF timing and in the context of tags the IAG TDM protocol
TIA	Telecommunications Industry Association
TS	Technical Specifications

1.7 Other Readers

Testing was performed for a 3M reader, a Janus MPR 2.3 reader with older generation radio module, and a Star reader, plus ATA 2200 RF module.

1.8 Outdoor Testing with vehicles

Plans: Future outdoor controlled access test lane and tolling site testing may be performed and will be reported from time to time.

1.8.1 Outdoor Test Variables

Testing outdoors introduces many variables such as:

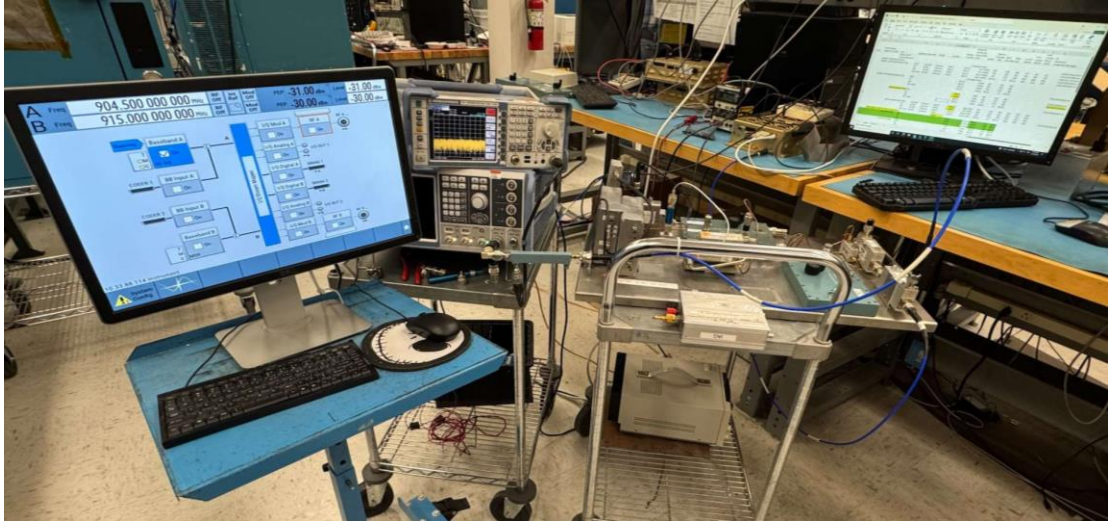
- Difficulty in re-creating 5G signals in licensed manner
- Different losses depending upon surrounding buildings, terrain, metal structures and forest
- Vehicle differences
- Surrounding vehicle reflections and shielding
- Tag mounting differences
- Handset placement and usage variations
- Data transmission timing from handset while tag is within the read zone trying to communicate

Outdoor testing also requires FCC experimental licensing.

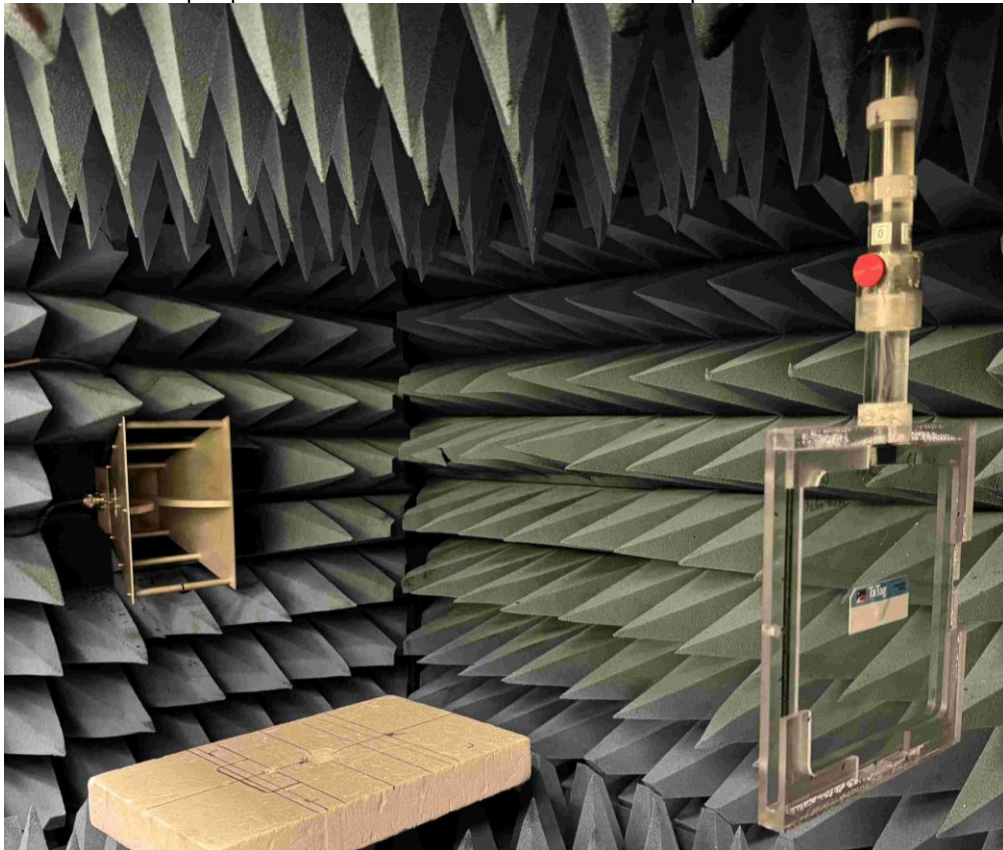
2. BENCH TEST SETUP

The Bench testing was split into two phases with separate setups testing both 5G base station and handset interference frequencies:

- Reader Bench Test with tag in a box where 5G interference is directed to the reader
 - o Separate test steps are made at the 5G base station frequencies and
 - o Test steps specific to 5G interference from Handset frequencies



- Tag in an anechoic chamber where 5G Interference is directed to the tag
 - o Separate test steps are made at the 5G base station frequencies and
 - o Test steps specific to 5G interference from Handset frequencies



NEXTRAV 5G NR INTERFERENCE TOLERANCE TESTING TO E6 & OTHER READERS & TAGS

With the reader, generator, amplifier, and spectrum analyzers used in tag testing shown here:



2.1 Test Plan

TransCore used as the basis the test plan titled "Lab_Interference_Test_250206_Final.doc" prepared by the group of manufacturers and tolling agency technical representatives in February of 2025.

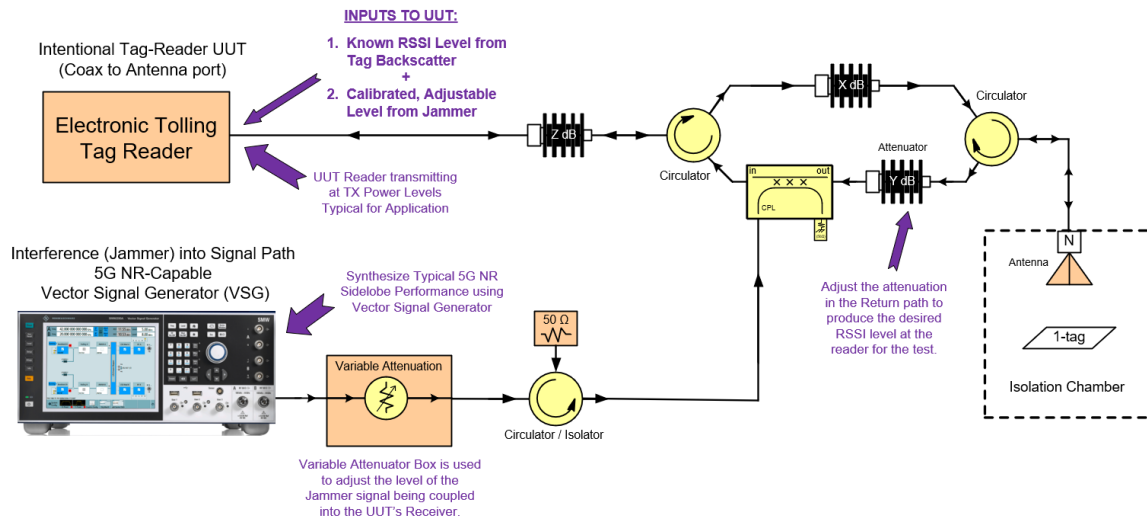
The reader frequencies are picked to be those that are licensed and used on the E6 for multiple protocols that include 6C high speed signaling data rate, requiring reader center frequencies to be further from the band edge than some other readers. This means the three channels as licensed today for backscatter are 912, 915.75, and 919.5 MHz, where the bandwidth of the two outside frequencies is as close to the sub-band edge as allowed by the equipment authorization grant.

In the test, the three frequencies used for backscatter are 909.25 MHz, 912, and 915.75, the latter which also happens to be the existing TDM frequency. Thus, the backscatter frequencies are 2.25 MHz in from the sub-band edge of the proposed tolling band.

2.2 Reader Bench Test

The reader bench test generally followed the test plan as shown in the introduction above:

Simplified Diagram of an Interference-On-Reader Test Set-up
(Setup for RFID Reader Characterization with 5G NR Jammer)

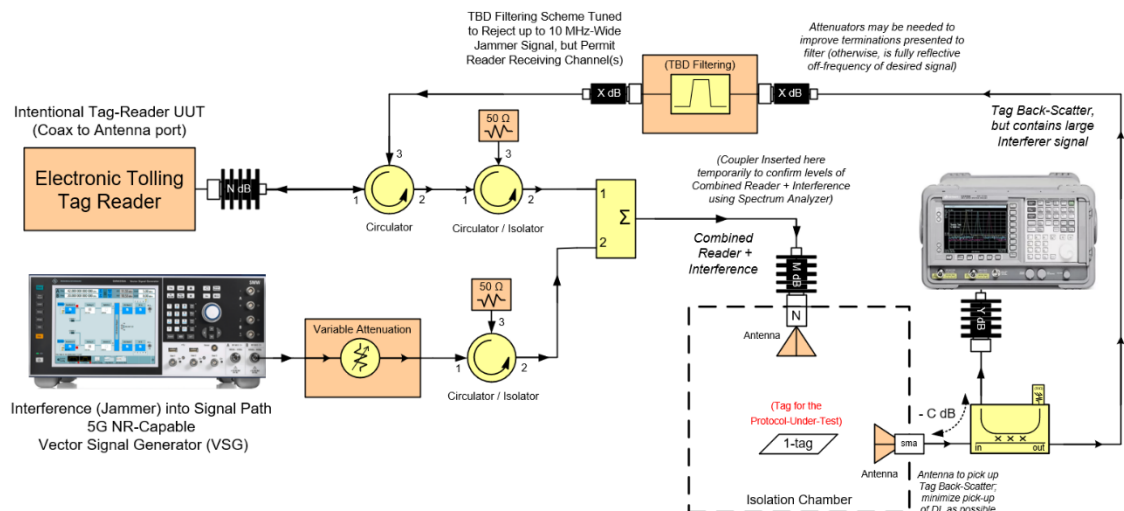


2.3 Tag Setup with Anechoic Chamber

The Tag testing included placing the tag on glass in an anechoic chamber with an antenna having the combined reader and 5G Interference from the signal generator, as driven by a variety of components as shown in the previous photographs including:

- Circulators
- Loads
- Fixed and Variable Attenuators
- PIN Attenuator switches driven by E6 reader signal for uplink blanking to provide only downlink to tag susceptibility measurements
- Amplifier and several spectrum analyzers (including monitor signals from the reader, tag (zero span response observation), and 5G interference

Simplified Diagram of an Interference-On-Tag Test Set-up



2.4 Tags and Protocols tested

A variety of tags were tested for each of the three protocols, TDM, SeGo, and 6C, and where multiple protocols were in the tag, each of those protocols were tested.

2.5 Test Data Collection

Detailed RF levels were collected to document the baseline of no interference threshold for tag reading and the interference to signal I/S Degradation ratios. As TransCore normally does, the handshake reduction in RF level was recorded when handshakes were reduced to 90%, 50% and 5% or less (& misses).

During tag testing, blanking of uplink backscatter signals was included to make sure the tag was only seeing interference on the downlink.

2.6 5G Waveforms

Section 1.4.1 details the 5G waveforms used as specified by NextNav and used in tests by other vendors.

2.6.1 Base Station

- 3GPP TS 38.141-1
- 10 MHz width for the proposed 918 to 928 MHz base station
 - o With an added step of also testing interference tolerance if a new TDM product were tuned to the middle of the resulting tolling allocation at 912.5 MHz by moving the 5G base station to 921.25 to 931.25 MHz
- 15 KHz sub-carrier spacing (SCS) with the smallest guard band of 250 kHz
- NRFR1-TM1.1 (FDD_10MHz _15kHz) Section 4.9.2.2.1 with primary usage of PDSCH and all resource blocks at same power level

2.6.2 User Equipment Handset

Handset interference waveforms were defined as

- 3GPP TS 38.141-1
- Fixed Reference Channel G-FR1-A1-1 for the 5 MHz 902 to 907 MHz band with 15 kHz subcarriers, Appendix A-1 with PUSCH (physical uplink shared channel)

2.7 Frequency Settings

The reader frequencies are picked to be those that are licensed and used on the E6 for multiple protocols that include the 6C high speed signaling data rate, requiring reader center frequencies to be further from the band edge than some other readers. Under the current band plan the three channels used for backscatter were: 912, 915.75, and 919.5 MHz, where the bandwidth of the two outside frequencies is as close to the sub-band edge as allowed by the equipment authorization grant.

Using the same offset from proposed 918 MHz sub-band edge as currently used, the tested backscatter frequencies are 909.25, 912.5, and 915.75 MHz for the proposed 11 MHz tolling band with no guard band.

Frequencies used by the reader included the closest backscatter channels to the adjacent proposed 5G base station band edge and handset band edge. The signal generator for the base station simulation is centered on 923 MHz (for 918-928 signals over the 10 MHz width, with handset simulation centered on 904.5 MHz for that 5 MHz wide signal, plus center frequencies and furthest away frequency.

TDM frequency of 915.75 MHz used as in the current TDM product, are offset from 918 MHz sub-band edge by 2.25 MHz.

Testing also looked at what improvements might be possible by offsetting TDM tags and reader transmit and hence receiving frequencies to the new center of the proposed band 912.5 MHz, achieving 5.5 MHz

offset between toll carrier frequencies and the proposed DL sub-band edge. This was simulated with the existing TDM tags by setting the 5G base signal generator to a lower edge frequency of 921.25 MHz (centered on 926.25 MHz).

2.8 Limitations and Challenges

Sometimes a tag does not show complete interference (5% HS rate or no handshakes) at the maximum RF power the signal generator with external circulators and various attenuators can deliver even though an amplifier is also employed. A Maximum of +7.4 dBm could be delivered and only a few cases saw the absence of full jamming.

It is often difficult to get a 50% handshake level with a different setting than recorded at 90% (or no reads) of full handshake rate.

Some TDM tags respond to glitches in the noise at unusual times resulting in false triggering, so the blanking of the interference during uplink also helps control handshakes to only be triggered during downlink signal for that tag protocol being interrogated. Separately, false triggering was observed.

3. FINDINGS

Interference was seen that can significantly reduce the handshakes leading to incorrect tag to lane voting, or misses (non-reads) in tolling from this benchtop investigation.

Handshake reduction and misses are indicated from bench top testing in all modes of interference,

- 5G Base Station to Tag
- 5G User equipment Handheld cellphone to Tag
- 5G Base Station to Reader
- 5G User equipment Handheld cellphone to Reader

Furthermore, interference is still seen for a potential re-designed frequency offset for IAG TDM protocol tags and readers to the proposed new band center of 912.5 MHz, as indicated by "IAG-future" lines in data.

The findings are portrayed for the described cases in this static bench test setup. While arguments may be made that tags can be slightly stronger, or a few handshakes may still be present at higher 5G levels, such reasoning does not consider many additional stresses in tag reading when combined with interference may cause missed tags:

- Reflections of the 5G signals off the same vehicle metal or other vehicles often occur at levels of 3 to 8 dB increase of the 5G interference
- Reader to tag and back null zones are also present
- Noise or other positional impairments may be present

Thus, for the high-performance levels expected in tolling, the communication signaling rate should be considered. The testing with the E6 included high data-rate 6C (normally used in current multi-protocol E6 firmware) and medium data-rate 6C uplink backscatter. High-speed data is presented, and medium speed data does not improve more than 3dB.

The data shows interference can occur from 5G adjacent sub-band (Lower 900 MHz) equipment hundreds or thousands of feet away, extending to over several miles in certain cases, even when 5G modeling is applied.

3.1 High Level Findings

The data shows concerns for all 4 modes of interference on one or more protocols with both handshake reduction and tag misses predicted.

- Base Station to Reader
- Base Station to Tag
- User equipment including cellphone handset with this 5G band to Tag
- And even 5G handset to reader when using the TDM protocol

Table generated with cases for each interference path and protocol:

- Worst Case – the full base station power of 20,000 watts over 10 MHz with most sensitive tag as measured by lowest level interference that causes the start of handshake misses as measured by 90% handshake rate to the no interference rate. Reader power at 3 dB above the tag wakeup threshold with no 5G interference turned on.
 - o For Handset interference, worst is the full power NextNav claims will be used, 200 mW, or 22.85 dBm with average susceptibility example tag for that protocol
 - o Note that NextNav asks for the full 3-watt user equipment rules, meaning interference could be over 10 dB worse for the handset case, but mounting of the antennas may be different, possibly mitigating to some extent
 - o Maximum case tag sensitivities highlighted in yellow
- Typical – the typical base station power of about 3890 Watts over the 10 MHz base station emissions, with an average tag susceptibility to interference.
 - o Typical Handset to tag interference is at 5 dB less, or 17.85 dBm with average tag susceptibility example tag for that protocol.

NEXTNAV 5G NR INTERFERENCE TOLERANCE TESTING TO E6 & OTHER READERS & TAGS

- Lab – most sensitive takes the typical base station RF level rounded to 66 dBm along with the second most sensitive tag of that protocol.
- The analysis does not take into account how many tags are in usage so distribution quantities in the local area can affect probability of interference also.

The possible impact of redesigning tags and readers to a new band center frequency was tested by offsetting the 5G base station 10 MHz from 918-928 MHz to the 5.5 MHz new sub-band edge offset spanning 921.25 to 931.25 MHz with center at 926.25 MHz. Note that this would only be possible for new tags and does not apply to the tags already deployed. Details of these tests are in the following sections.

- Base Station to Tag testing showed only an average of 2.6 dB reduction in interference levels over the 5 tag products tested (average interference 90% HS levels went from -13 dBm to -10.4 dBm)
- Base Station to Reader testing showed a 5 dB improvement in interference thresholds from -65.6 dBm to -60 dBm

Similarly, the possible redesign of tags and readers to the center of the new band was tested in the context of handset user equipment (cellphones) in the car. Since this aspect of redesign would move the IAG TDM protocol frequency closer to the handset frequency, more interference was found to the reader in those brief times of transmissions, which may be extended with retries if there is interference also to the 5G system.

- Handset to tag showed no significant change going from -13.0 to -12.8 dBm if a new offset was implemented.
- Handset to reader testing shows a significant increase in reader susceptibility if products are redesigned for a center of band change of the TDM protocol: 16 dB worse interference susceptibility, from -52.1 to -68 dBm threshold, meaning significantly more jamming if the handset bursts occur in the read zone.

False Triggering of TDM tags occurs when the 5G signal appears to be a 20-microsecond wakeup trigger to cause the tag response without a reader being interrogating. Appendix 4.5 has details of the false triggering RF levels at the tag from 5G signals, with distance estimates worst case. Additional battery current drain may be present in some models of tags even without the tag response as the tag evaluates and qualifies the signal.

3.2 Base Station Interference to Tag

The detailed analysis of 5G Base Station interference to each of 22 tags for RF susceptibility in an RF anechoic chamber is summarized in this section by tag protocol for the closest frequency. Additional backscatter data is provided in the appendix for the other 2 reader channels, the mid and far frequency from the source.

This data is for the reader set to a tag wake-up of +3 dB signal margin

RF levels to the tag are of concern not only for tag reading but also for the battery tags (typically the tags with the TDM protocol) as they travel or are parked near the proposed 5G sites where the battery is depleted. See section 4.5 for data gathered from just 5G signals false triggering several tag models.

6C tag data for base station to tag in dBm

5G Base to Tag Protocol	Tag model	Tag #	Reader/Tag Freq MHz	Baseline Reader RX dBm level +3dB, no 5G	dBm Level for 90% HS	dBm Level causing 50% HS	dBm Level causing Miss or 5% HS
6C	NP2	1	915.75	-10	-14	-13	-12
6C	GeauxP NXP	6	915.75	-12	-17		-16
6C	Fast SW AH9	7	915.75	-16	-21		-20
6C	Exp ST AH3	8	915.75	-11	-17	-16	-15
6C	Imp Monz 4QT	9	915.75	-10	-19		-18
6C	Imp Monz R6	10	915.75	-14	-19	-18	-17
6C	Imp Monz 5	11	915.75	-3	-9		-8
6C	Tag I Impinj	12	915.75	-11	-16		-15
6C	Tag D Impinj	13	915.75	-19	-23		-22
6C	AD 663 NXPXTID	14	915.75	-9	-13		-12
6C	AD 324 NXPXTID	15	915.75	-5	-10		-9
6C	AD 383 NXPXTID	16	915.75	-12	-24	-23	-22
				Average	-16.8		

SeGo tag data for base station to tag

5G Base to Tag Protocol	Tag model	Tag #	Reader/Tag Freq MHz	Baseline Reader RX level dBm +3dB, no 5G	dBm Level for 90% HS	dBm Level causing 50% HS	dBm Level causing Miss or 5% HS
SeGo	NP2	1	915.75	-7	-12		-11
SeGo	eGo+ Dual 6C ST	17	915.75	-5	-7		-6
SeGo	GoAP3 +6C	18	915.75	-7	-12		-11
SeGo	SeGo MM ST	19	915.75	-5			-11
SeGo	SeGo MM TxTag	20	915.75	-10	-18	-14	-13
SeGo	KTag	21	915.75	-8	-18	-12	-11
SeGo	SeGo MM	22	915.75	-12	-15	-12	-11
				average	-13.7		

NEXTNAV 5G NR INTERFERENCE TOLERANCE TESTING TO E6 & OTHER READERS & TAGS

TDM for Base Station to Tag, for 918-928 MHz (CF 923 MHz), with the IAG-future test offsetting 5G signal generator to CF (center frequency) 926.25 MHz

5G Base to Tag Protocol	Tag model	Tag #	Reader/Tag Freq MHz	Baseline Reader RX level dBmi +3dB, no 5G	dBmi Level causing 90% HS	dBmi Level causing 50% HS	dBmi Level causing Miss or 5% HS
IAG-TDM	NP2	1	915.75	-12	-16	-15	-14
IAG- future	NP2	1	915.75	-12	-16	-15	-14
IAG	G4	2	915.75	-10	-13		-11
IAG- future	G4	2	915.75	-10	-10		-8
IAG	G5	3	915.75	-9	-10		-9
IAG- future	G5	3	915.75	-9	-8		-4
IAG	JED III	4	915.75	-10	-12		-11
IAG- future	JED III	4	915.75	-10	-10		-8
IAG	JED II	5	915.75	-10	-14		-13
IAG- future	JED II	5	915.75	-10	-8		-7
				Average	-13		
				future avg	-10.4		

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3.2.1 Modeled distance standoff Base Station to Tag

Evaluating the three cases of interference severity, Worst, Typical, and Lab using the 2nd most sensitive tag, for each tag protocol we find the following indications of stand-off distance to prevent interference:

5G Base Station to 6C Tag – RF levels between 6C tags as measured by tag sensitivity or interference susceptibility vary widely and this is seen in the worst-case distances for concern as shown in the table below. The 5G path loss models and free space models are reported in meters standoff worst case needed for these line-of-sight conditions:

5G Base to Tag RF level Summary Cases	5G Intf Watts	5G Intf dBm	6C Tag #	Tag Sens dBmi +3dB	90% HS Intf level dBmi	Path Loss dB	UMa-LOS meters	RMA-LOS meters	UMI-LOS meters	FSPL meters
Worst	20,000	73.00	16	-12.00	-24.00	97.00	506	1126	462	1848
Typ-Avg	3,890	65.90	13	-19	-17.00	82.90	224	325	204	364
Lab-2nd most	3,981	66.00	6 & 8	-12.00	-23.00	89.00	319	618	292	736

5G Base Station to SeGo Tag worst case with the 5G Path Loss models:

5G Base to Tag RF level Summary Cases	5G Intf Watts	5G Intf dBm	SeGo Tag #	Tag Sens dBmi +3dB	90% HS Intf level dBmi	Path Loss dB	UMa-LOS meters	RMA-LOS meters	UMI-LOS meters	FSPL meters
Maximum	20,000	73.00	20	-10.00	-18.00	91.00	358	758	327	926
Typ-Avg	3,890	65.90	1	-7.00	-12.00	77.90	167	187	152	205
Lab-2nd most	3,981	66.00	22	-12.00	-15.00	81.00	200	264	182	293

5G Base to TDM protocol tag interference also provides concern since this can not only impact tag reading (with cell sites often only a few hundreds of feet away), but tags can also be triggered awake anywhere a tag is close to the proposed 5G site, further depleting the battery prematurely as shown in section 4.5.

5G Base to Tag RF level Summary Cases	5G Intf Watts	5G Intf dBm	IAG Tag #	Tag Sens dBmi +3dB	90% HS Intf level dBmi	Worst Case dB	UMa-LOS meters	RMA-LOS meters	UMI-LOS meters	FSPL meters
Worst	20,000	73.00	1	-12	-16	89.00	319	618	292	736
Typ-Avg	3,890	65.90	4	-10	-12	77.90	167	187	152	205
Lab-2nd most	3,981	66.00	5	-10	-14	80.00	189	236	172	261

3.3 User Equipment – Cellphone Handset - interference to tag

The detailed data below by tag protocol shows the impact of 5G user equipment such as cell phones handheld or within the vehicle upon the tags directly based upon just the reader downlink. Thus, influence of the 5G signals upon the uplink to the reader is eliminated in this data section. This section includes just the closest adjacent backscatter frequency, with the middle frequency channel and far frequency from the handheld signals in the appendix.

For this data the 5G signal generator is set to a 5 MHz bandwidth from 902 to 907 MHz as proposed by NextNav. Additionally, data was collected for the IAG protocol with the signal generator offset in frequency to 905.25 to 910.25 (FC=907.75 MHz) so that a future IAG offset product only 5.5 MHz from the 5G sub-band edge is evaluated.

6C interference levels to tag from 5G handheld

5G Handset to Tag Protocol	Tag model	Tag #	Reader /Tag Freq MHz	Baseline Reader RX level dbmi +3dB, no 5G	dbmi Level for 90% HS	dbmi Level causing 50% HS	dbmi Level causing Miss or 5% HS
6C	NP2	1	909.25	-11	-15		-14
6C	GeauxP NXP	6	909.25	-13	-20		-19
6C	FasT SW AH9	7	909.25	-16	-23	-22	-21
6C	Exp ST AH3	8	909.25	-12	-18		-17
6C	Imp Monz 4QT	9	909.25	-11	-21		-20
6C	Imp Monz R6	10	909.25	-15	-23	-22	-21
6C	Imp Monz 5	11	909.25	-4	-11		-10
6C	Tag I Impinj	12	909.25	-12	-19	-18	-17
6C	Tag D Impinj	13	909.25	-20	-27		-26
6C	AD 663 NXPXTID	14	909.25	-10	-15		-14
6C	AD 324 NXPXTID	15	909.25	-6	-12		-10
6C	AD 383 NXPXTID	16	909.25	-12	-20	-18	-17
6C	GoAP3 +6C	18	909.25	-10	-14		-13
				average	-18.3		

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5G handheld signals to SeGo interference levels

5G Handset to Tag Protocol	Tag model	Tag #	Reader /Tag Freq MHz	Baseline Reader RX level dbmi +3dB, no 5G	dbmi Level for 90% HS	dbmi Level causing 50% HS	dbmi Level causing Miss or 5% HS
SeGo	NP2	1	909.25	-8	-15		-14
SeGo	eGo+ Dual 6C ST	17	909.25	-6	-9		-8
SeGo	GoAP3 +6C	18	909.25	-6	-13		-12
SeGo	SeGo MM ST	19	909.25	-6	-14		-13
SeGo	SeGo MM TxTag	20	909.25	-11	-16	-15	-14
SeGo	KTag	21	909.25	-8	-15	-12	-11
SeGo	SeGo MM	22	909.25	-10	-16		-13
				average	-14.0		

IAG TDM data includes the measurement of future possible tag and reader operating at center of shifted band with less separation from the handheld 5G signals. The Salmon highlighted cells had no loss of reads at full power

5G Handset to Tag Protocol	Tag model	Tag #	Reader /Tag Freq MHz	Baseline Reader RX level dbmi +3dB, no 5G	Signal Generator Center Freq	Offset from edge	dbmi Level for 90% HS	dbmi Level causing 50% HS	dbmi Level causing Miss or 5% HS
IAG	NP2	1	915.75	-12	904.5	8.75	-18	-17	-16
IAG- future	NP2	1	915.75	-12	907.75	5.5	-18	-16	-15
IAG	G4	2	915.75	-10	904.5	8.75	-10		-7
IAG- future	G4	2	915.75	-10	907.75	5.5	-14		-11
IAG	G5	3	915.75	-9	904.5	8.75	-11		-8
IAG- future	G5	3	915.75	-9	907.75	5.5	-14		-12
IAG	JED III	4	915.75	-10	904.5	8.75			0
IAG- future	JED III	4	915.75	-10	907.75	5.5	-8		-6
IAG	JED II	5	915.75	-10	904.5	8.75			0
IAG- future	JED II	5	915.75	-10	907.75	5.5	-10		-8
IAG	GoAP3 +6C	18	915.75	-10	904.5	8.75			-23
IAG- future	GoAP3 +6C	18	915.75	-10	907.75	5.5			-23
						IAG Avg	-13.0		
					IAG future Average		-12.8		

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3.3.1 Modeled distance Handset to Tag

While User equipment rules proposed by NextNav would allow 3 watts ERP from user equipment, the testing was performed for nearly 200 milliwatts (193 milliwatts per -22.85 dBm) as the worst case expected usage inside the vehicle. Typical and lab values were at 61 and 62 milliwatts (17.85 and 17.9 dBm respectively). The details below do show interference is possible for nearly all positions of cellphone usage in the front driver and passenger seats with interference also possible from the next row back and even the third row of seats for 6C. Of course, shielding and reflections to degrade or enhance signals will certainly be present in some locations of the handset and people.

Details of 5G Handset to 6C Tag testing with the distance computed for line-of-sight modeled

5G Handset to Tag RF level Summary	5G Intf Watts	5G Intf dBm	6C Tag #	Tag Sens - dBmi +3dB	90% HS Intf level dbmi	dB	Tag INH-LOS meters	FSPL meters
Worst	0.193	22.85	13	-20.00	-27.00	49.85	10	8
Typ-Avg	0.061	17.85	8	-12.00	-18.00	35.85	2	2
Lab-2nd most	0.062	17.90	7	-16.00	-23.00	40.90	3	3

Details of 5G Handset to SeGo Tag testing with the distance computed for line-of-sight free space

5G Handset to Tag RF level Summary	5G Intf Watts	5G Intf dBm	SeGo Tag #	Tag Sens dBmi +3dB	90% HS Intf level dbmi	dB	Tag INH-LOS meters	FSPL meters
Worst	0.193	22.85	20	-11.00	-16.00	38.85	3	2
Typ-Avg	0.061	17.85	19	-6.00	-14.00	31.85	1	1
Lab-2nd most	0.062	17.90	1	-8.00	-15.00	32.90	1	1

Details of 5G Handset to TDM Tag testing with the distance computed for line-of-sight free space

5G Handset to Tag RF level Summary	5G Intf Watts	5G Intf dBm	IAG Tag #	Tag Sens dbmi +3dB	90% HS Intf level dbmi	dB	Tag INH-LOS meters	FSPL meters
Worst	0.193	22.85	1	-12	-18	40.85	3	3
Typ-Avg	0.061	17.85	3	-9	-11	28.85	1	1
Lab-2nd most	0.062	17.90	2	-10	-10	27.90	1	1

3.4 Base station interference to Reader

The 5G base station interference levels to the reader were measured on the E6 backscatter frequency of 915.75 MHz, the closest reader channel allowed under the current equipment authorization to the 5G base station frequency. This is also the frequency of the current IAG TDM tags. As noted on “future” line, the 5G signal generator was also shifted to test the effect of designing new reader and tag products to work in the center of the proposed band, with test data showing a 5 dB tolerance increase from interference from just the base station, however handset interference to reader got worse with the proposed TDM frequency shift as shown in that section..

Tolling backscatter protocol (SeGo and 6C) installations use separate channels across the tolling sub-band for each antenna in order: 915.75, 912.5, and 909.25 to fill out the proposed 907 to 918 MHz band with the reader downlink emissions to the tag. Slightly higher RF levels of interference could be tolerated further for the SeGo and 6C protocols

The bench testing setup maxed out the signal generator settings at Plus 7.4 dBm for the SeGo protocol, whereas the 6C protocol interference started at -5.6 dBm, a difference of 13 dB.

E6 Reader Tag Protocol	Rdr/Tag Freq MHz	Baseline Reader RF Port RX level +3dB, no 5G	Sign Gen Freq edge, MHz	Offset from edge	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
		3 dB signal margin					
SeGo	915.75	-54.4	918	2.25	-5.6	-4.6	-3.6
6C	915.75	-47.4	918	2.25	-8.6	-6.6	-5.6
IAG	915.75	-58.27	918	2.25	-65.6	-64.6	-62.6
IAG- future	915.75	-58.27	921.25	5.5	-60.6	-59.6	-57.6

SeGo	912.5	-54.4	918	5.5	-4.6	-3.6	-2.6
6C	912.5	-47.4	918	5.5	-7.6	-5.6	-4.6

SeGo	909.25	-54.4	918	8.75	7.4		
6C	909.25	-47.4	918	8.75	-5.6	-4.6	-2.6

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3.4.1 Modeled distance standoff base station to reader

The -dBm values above are difficult to appreciate until they are converted into distances to keep 5G base stations away to be assured of no interference. 6C data shown below for the TransCore TIB (Tag in Box).

5G Base to E6 RF level Summary	5G Intf Watts	5G Intf dBm	6C Tag #	Tag Sens - dBm +3dB	90% HS Intf level -dBm	dB	UMa-LOS meters	RMA-LOS meters	UMI-LOS meters	FSPL meters
Worst	20,000	73.00	TIB	-47.40	-8.60	81.60	293	280	237	311
Typ-Avg	3,890	65.90	TIB	-47.40	-8.60	74.50	139	126	109	137

SeGo Tag in Box data:

5G Base to E6 RF level Summary	5G Intf Watts	5G Intf dBm	SeGo Tag #	Tag Sens - dBm +3dB	90% HS Intf level -dBm	dB	UMa-LOS meters	RMA-LOS meters	UMI-LOS meters	FSPL meters
Worst	20,000	73.00	TIB	-54.40	-5.60	78.60	214	201	171	220
Typ-Avg	3,890	65.90	TIB	-54.40	-5.60	71.50	100	88	78	97

IAG TDM Tag in Box data – note TDM is much more sensitive to interference as the previous Progeny testing showed. 5G path loss models, plus the non-line of sight model distance, and free space distances are shown below.

5G Base to E6 RF level Summary	5G Intf Watts	5G Intf dBm	IAG Tag #	Tag Sens - dBm +3dB	90% HS Intf level -dBm	dB	UMa-LOS meters	RMA-LOS meters	RMA Non-Line of Sight meters	UMI-LOS meters	FSPL meters
Worst	20,000	73.00	TIB	-58	-65.6	138.60	>5K	8,548	4,274	>5K	222,116
Typ-Avg	3,890	65.90	TIB	-58	-65.6	131.50	>5K	7,061	2,799	>5K	98,080

3.4.2 Signal Margin Comparisons

The testing included a comparison of signal margin setting differences at the reader as bench tested with the TransCore reference tag in the box.

It should be noted that not all mounted tags on vehicles will have similar signal margins. Furthermore, setting higher signal margins may not be possible with installed cable losses. The uncertainty of correlating a tag to a specific vehicle becomes greater with high signal margins in some lane installations.

Tag model	Baseline Reader RX level, no 5G	Sign Gen Freq edge, MHz	Offset from edge	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
Baseline, 3 dB above sensitivity						
SeGo TIB	-54.4	918	2.25	-5.6	-4.6	-3.6
6C TIB	-47.4	918	2.25	-8.6	-6.6	-5.6
IAG TIB	-58.27	918	2.25	-65.6	-64.6	-62.6
IAG TIB Future	-58.27	921.25	5.5	-60.6	-59.6	-57.6
3 dB signal margin (This is 6 dB above sensitivity)						
SeGo TIB	-51.4	918	2.25	-5.3	-4.6	-3.6
6C TIB	-44.4	918	2.25	-8.1	-6.8	-5.6
IAG TIB	-55.27	918	2.25	-62.6	-61.6	-60.4
IAG TIB Future	-55.27	921.25	5.5	-57.7	-56.6	-54.6
6 dB signal margin (This is 9 dB above sensitivity)						
SeGo TIB	-48.4	918	2.25	-4.6	-4	-2.6
6C TIB	-41.4	918	2.25	-7.1	-6.1	-4.6
IAG TIB	-52.27	918	2.25	-59.6	-58.7	-57.6
IAG TIB Future	-52.27	921.25	5.5	-55.1	-53.9	-52.6

3.5 Handset interference to Reader

Under the NextNav proposal the 5G user equipment (cellphone handsets) would be transmitting bursts of data that may occur when the vehicle is under the reader antenna, in the read zone and that 902 to 907 MHz interference tolerance level was tested for the various protocols. Below are the RF levels of 5G handset signals as received by the reader overhead for the different handshake successful read percentage values as compared to no interference.

Presented is data for the closest reader frequency 909.25 MHz channel allowed under the 2.25 MHz closest offset of the reader to the sub-band edge as allowed under the current FCC grant, as adjusted for the proposed 907 MHz NextNav uplink sub-band edge from the handset.

The data includes a possible future IAG TDM design change to adjust tag TX and reader RX frequencies to the center of the new band proposed by NextNav. In this case IAG TDM tolerance to handset interference worsens by 16 dB since the new design frequency would be closer to the handset interference. Salmon colored cells indicate maximum RF signal generation with amplification at +7.4 dBm reached and further increases not available to find actual values or further reduced handshake responses or the missed tag level.

The other 2 backscatter channels of 912.5 and 915.75 are also shown in the data. The differences are highlighted where the signal generator was maxed out at +7.4 dBm before the handshake reduction was encountered.

E6 Reader Tag Protocol	Rdr/Tag Freq MHz	Baseline Reader RX level +3dB, no 5G	Sign Gen Freq edge, MHz	Offset from edge	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
SeGo	909.25	-54.4	907	2.25	-5.1	-4.5	-3.7
6C	909.25	-47.4	907	2.25	-7.6	-6.6	-5.6
IAG	915.75	-58.27	907	8.75	-52.1	-51.2	-50
IAG- future	915.75	-58.27	910.25	5.5	-68	-67.1	-66.1

SeGo	912.5	-54.4	907	-5.5	7.4		
6C	912.5	-47.4	907	-5.5	-4.6	-2.6	7.4

SeGo	915.75	-54.4	907	-8.75	7.4		
6C	915.75	-47.4	907	-8.75	-3.6	7.4	

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3.5.1 Modeled Distance Handset to Reader

The Handset, when in the typical dash location, passes under the antenna, so line of sight modeling was applied in calculating the distance to keep away to assure no interference as indicated by bench testing.

6C data shows little impact expected from the low power handset transmissions. These tables also include a typical antenna gain of 13 dB (some models are 12 dB and other models are 14 dB)

5G Handset to Reader RF level Summary	5G Intf Watts	5G Intf dBm	6C Tag #	Reader Sens - dBm +3dB	90% HS Intf level -dBm	dB with 13 dB Ant Gain	Loss Model Tag INH-LOS meters	FSPL meters
Worst	0.193	22.85	TIB	-47.40	-7.60	43.45	2	3.8
Typ-Avg	0.061	17.85	TIB	-47.40	-7.60	38.45	<1	2.18

SeGo data also shows little impact from the handset

5G Handset to Reader RF level Summary	5G Intf Watts	5G Intf dBm	SeGo Tag #	Reader Sens - dBm +3dB	90% HS Intf level -dBm	dB with 13 dB Ant Gain	Loss Model Tag INH-LOS meters	FSPL meters
Worst	0.193	22.85	TIB	-54.40	-5.10	40.95	<1	2.91
Typ-Avg	0.061	17.85	TIB	-54.40	-5.10	35.95	<1	1.64

IAG TDM data shows a significant possibility of interference due to the close proximity of the handset to the reader when a tagged car passes below the antenna in the read zone. While handset transmissions are only intermittent, this worst case can occur, and if there is reader to cellphone jamming, retries may then continue the interference from the handset

5G Handset to Reader RF level Summary	5G Intf Watts	5G Intf dBm	IAG Tag #	Reader Sens - dBm +3dB	90% HS Intf level -dBm	dB with 13 dB Ant Gain	Loss Model Tag Umi-LOS meters	FSPL meters
Worst	0.193	22.85	TIB	-58	-52	87.95	123	652 m
Typ-Avg	0.061	17.85	TIB	-58	-52	82.95	97	366 m

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4. APPENDIX FOR BACKSCATTER MID AND FAR OFFSET E6 FREQUENCIES

This data documents cases where the offset between the frequency of the 5G is increased due to the other two backscatter frequencies being used for E6 SeGo and 6C tag reading. To prevent adjacent antenna interference in open road and conventional tolling plazas with 3 or more readers, all three frequencies must be used at the sites:

909.25, 912.5, and 915.75 MHz for the proposed 11 MHz tolling band with no guard band.

In the tables below, the grey 50% handshake cells, without numeric data, mean finding 50% response rate was not possible – quick transition from 90% to 5% or misses

The data is organized in the order of:

- Base Station to Backscatter Tag on Mid Frequency 912.5 MHz
- Base Station to Backscatter Tags on Far Frequency 909.25 MHz
- Handset to Backscatter Tags on Mid Frequency 912.5 MHz
- Handset to Backscatter Tags on Far Frequency 915.75 MHz

Within each section SeGo and then 6C tags are shown

NEXTNAV 5G NR INTERFERENCE TOLERANCE TESTING TO E6 & OTHER READERS & TAGS

4.1 Base Station to Backscatter Tags on Mid Frequency used by E6 Reader

SeGo Backscatter frequency set to center of proposed 907-918 MHz tolling band for measurements with 918-928 MHz 5G Base Station signals.

Base to Mid Freq E6 Tag Protocol	Tag model	Tag #	Reader /Tag Freq MHz	Baseline Reader RX level +3dB, no 5G	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
SeGo	NP2	1	912.5	-8	-14	-13	-12
SeGo	eGo+ Dual 6C ST	17	912.5	-5	-6	-5	-4
SeGo	GoAP3 +6C	18	912.5	-7	-12		-11
SeGo	SeGo MM ST	19	912.5	-6	-12		-11
SeGo	SeGo MM TxTag	20	912.5	-11	-15		-13
SeGo	KTag	21	912.5	-8	-15	-11	-10
SeGo	SeGo MM	22	912.5	-10	-13		-11
				Avg	-12.4		

6C Backscatter frequency set to center of proposed 907-918 MHz tolling band for measurements with 918-928 MHz 5G Base Station signals.

Base to Mid Freq E6 Tag Protocol	Tag model	Tag #	Reader /Tag Freq MHz	Baseline Reader RX level +3dB, no 5G	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
6C	NP2	1	912.5	-10	-14		-13
6C	GeauxP NXP	6	912.5	-13	-19	-18	-17
6C	FasT SW AH9	7	912.5	-16	-21		-20
6C	Exp ST AH3	8	912.5	-11	-17		-15
6C	Imp Monz 4QT	9	912.5	-10			-18
6C	Imp Monz R6	10	912.5	-14	-18		-17
6C	Imp Monz 5	11	912.5	-4		-10	-9
6C	Tag I Impinj	12	912.5	-12	-16		-15
6C	Tag D Impinj	13	912.5	-19		-22	-21
6C	AD 663 NXPXTID	14	912.5	-10			-13
6C	AD 324 NXPXTID	15	912.5	-5	-10	-9	-8
6C	AD 383 NXPXTID	16	912.5	-12	-17	-15	-14
6C	eGo+ Dual 6C ST	17	912.5	-10	-12		-11
6C	GoAP3 +6C	18	912.5	-11	-13		-12
				average	-15.7		

4.2 Base Station to Backscatter Tags on Far Frequency used by E6 Reader

SeGo Backscatter frequency set to 909.25 MHz the farthest frequency in the proposed 907-918 MHz tolling band from the proposed 918-928 MHz 5G Base Station signals

5G Base to Far Freq Tag Protocol	Tag model	Tag #	Reader /Tag Freq MHz	Baseline Reader RX level +3dB, no 5G	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
SeGo	NP2	1	909.25	-8	-13		-12
SeGo	eGo+ Dual 6C ST	17	909.25	-5	-5	-4	-3
SeGo	GoAP3 +6C	18	909.25	-6	-12	-11	-10
SeGo	SeGo MM ST	19	909.25	-6			-11
SeGo	SeGo MM TxTag	20	909.25	-11	-13		-12
SeGo	KTag	21	909.25	-8	-10		-8
SeGo	SeGo MM	22	909.25	-10	-14	-11	-10
				average	-11.2		

6C Backscatter frequency set to 909.25 MHz the farthest frequency from the proposed 907-918 MHz tolling band from the proposed 918-928 MHz 5G Base Station signals.

Base to Far Freq Tag Protocol	Tag model	Tag #	Reader /Tag Freq MHz	Baseline Reader RX level +3dB, no 5G	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
6C	NP2	1	909.25	-11	-15		-14
6C	GeauxP NXP	6	909.25	-13	-18		-17
6C	FasT SW AH9	7	909.25	-16	-21	-20	-19
6C	Exp ST AH3	8	909.25	-12	-17		-16
6C	Imp Monz 4QT	9	909.25	-10	-18		-17
6C	Imp Monz R6	10	909.25	-15	-19	-18	-17
6C	Imp Monz 5	11	909.25	-4	-10		-9
6C	Tag I Impinj	12	909.25	-12	-16		-15
6C	Tag D Impinj	13	909.25	-20	-23		-22
6C	AD 663 NXPXTID	14	909.25	-10			-13
6C	AD 324 NXPXTID	15	909.25	-6	-11	-10	-9
6C	AD 383 NXPXTID	16	909.25	-13	-16		-14
6C	eGo+ Dual 6C ST	17	909.25	-10	-12		-11
6C	GoAP3 +6C	18	909.25	-10	-13		-12
				average	-16.1		

4.3 Handset to Backscatter Tags on Mid Frequency used by E6 Reader

SeGo Backscatter frequency set to 912.5 MHz, the center frequency in the proposed 907-918 MHz tolling band, adjacent to handset 902-907 MHz 5G signals

5G Handset to Mid Tag Protocol	Tag model	Tag #	Reader /Tag Freq MHz	Baseline Reader RX level +3dB, no 5G	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
SeGo	NP2	1	912.5	-8	-16		-15
SeGo	eGo+ Dual 6C ST	17	912.5	-5	-8		-7
SeGo	GoAP3 +6C	18	912.5	-7	-13		-12
SeGo	SeGo MM ST	19	912.5	-6	-14		-13
SeGo	SeGo MM TxTag	20	912.5	-11	-16	-15	-14
SeGo	KTag	21	912.5	-8	-13		-11
SeGo	SeGo MM	22	912.5	-10	-14		-13
				average	-13.4		

6C Backscatter frequency set to 912.5 MHz the center frequency from the proposed 907-918 MHz tolling band, adjacent to handset 902-907 MHz 5G signals

5G Handset to mid freq 6C Tag Protocol	Tag model	Tag #	Reader /Tag Freq MHz	Baseline Reader RX level +3dB, no 5G	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
6C	NP2	1	912.5	-10	-15		-14
6C	GeauxP NXP	6	912.5	-13	-21	-20	-19
6C	Fast SW AH9	7	912.5	-16	-23	-22	-21
6C	Exp ST AH3	8	912.5	-11	-18		-17
6C	Imp Monz 4QT	9	912.5	-10		-20	-19
6C	Imp Monz R6	10	912.5	-15	-23		-22
6C	Imp Monz 5	11	912.5	-4	-12		-11
6C	Tag I Impinj	12	912.5	-12	-19	-18	-17
6C	Tag D Impinj	13	912.5	-19	-26		-25
6C	AD 663 NXPXTID	14	912.5	-10	-16	-15	-14
6C	AD 324 NXPXTID	15	912.5	-5	-11		-10
6C	AD 383 NXPXTID	16	912.5	-13	-20	-19	-18
6C	eGo+ Dual 6C ST	17	912.5	-10	-15	-14	-13
6C	GoAP3 +6C	18	912.5	-11	-14	-13	-12
				average	-17.9		

NEXTNAV 5G NR INTERFERENCE TOLERANCE TESTING TO E6 & OTHER READERS & TAGS

4.4 Handset to Backscatter Tags on Far Frequency used by E6 Reader

SeGo Backscatter frequency set to 915.75 MHz the farthest frequency from the proposed 907-918 MHz tolling band, adjacent to handset 902-907 MHz 5G signals

5G Handset to Far Freq SeGo Tag Protocol	Tag model	Tag #	Reader /Tag Freq MHz	Baseline Reader RX level +3dB, no 5G	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
SeGo	NP2	1	915.75	-7	-15		-14
SeGo	eGo+ Dual 6C ST	17	915.75	-5	-9	-8	-7
SeGo	GoAP3 +6C	18	915.75	-7	-14	-13	-12
SeGo	SeGo MM ST	19	915.75	-5	-13		-12
SeGo	SeGo MM TxTag	20	915.75	-10	-15		-14
SeGo	KTag	21	915.75	-8	-13		-11
SeGo	SeGo MM	22	915.75	-9	-14		-12
				average	-13.3		

6C Backscatter frequency set to 915.75 MHz the farthest frequency from the proposed 907-918 MHz tolling band, adjacent to handset 902-907 MHz 5G signals

5G Handset to Far Freq 6C Tag Protocol	Tag model	Tag #	Reader /Tag Freq MHz	Baseline Reader RX level +3dB, no 5G	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
6C	NP2	1	915.75	-10	-15		-14
6C	GeauxP NXP	6	915.75	-12	-20	-19	-18
6C	FasT SW AH9	7	915.75	-13			-20
6C	Exp ST AH3	8	915.75	-11	-19	-18	-17
6C	Imp Monz 4QT	9	915.75	-10	-21		-20
6C	Imp Monz R6	10	915.75	-14	-23	-22	-21
6C	Imp Monz 5	11	915.75	-3	-12		-11
6C	Tag I Impinj	12	915.75	-11	-18		-17
6C	Tag D Impinj	13	915.75	-19	-27		-26
6C	AD 663 NXPXTID	14	915.75	-9	-15		-14
6C	AD 324 NXPXTID	15	915.75	-5	-12		-11
6C	AD 383 NXPXTID	16	915.75	-12	-21		-19
6C	eGo+ Dual 6C ST	17	915.75	-10	-15		-14
6C	GoAP3 +6C	18	915.75	-11	-14	-13	-12
				average	-17.8		

4.5 False Triggering of TDM causing accelerated battery drain

The 5G signal generator was set up with a tag in a shielded anechoic chamber to understand the 5G RF levels causing different rates of tag false triggering (where a TDM frame response transmission is made by the tag) with the associated accelerated battery drain given extended dwell times in such signal levels. The required path loss and distance away for rural (73 dBm) and typical urban levels (66 dBm) worst case are also shown for the intermittent false triggering levels. Some tags have intermediate current drain levels to qualify RF signals even though they do not transmit following increased RF background levels. Grey cells mean the intermittent level could not be found and instead the continuous level was used.

The line for IAG-Future would be a redesigned product, but today's product was tested with signal generator frequency set further away for the 5.5 MHz offset for 5G to today's TDM frequency of 915.75 MHz.

5G RF levels Causing False Triggering	Protocol	Tag Model	BW MHz	Center Freq MHz Sig Gen	-dBm Intermit False Trig	-dBm Cont. False Trig	-dBm False Trig Stops	5G Intf dBm	5G to Tag DB Diff	Worst Case Keep away meters
5G Base-Tag	IAG-TDM	G4	10	923		-12	-10	73	85	464
						-12		66	78	207
	IAG- future	G4	10	926.25	-10	-9	-7			
5G HH-Tag	IAG-TDM	G4	5	904.5	-8	-4	-3	22.8	31	0.58
					-8			17.8	26	0.91
	IAG- future	G4	5	907.75	-12	-11	-9			
5G Base-Tag	IAG-TDM	G5	10	923	-10	-8	-5	73	83	368
					-10			66	76	165
	IAG- future	G5	10	926.25	-6	-4	0			
5G HH-Tag	IAG-TDM	G5	5	904.5	-7	-5	0	22.8	30	0.823
					-7			17.8	25	0.46
	IAG- future	G5	5	907.75	-4	-3	-2			
5G Base-Tag	IAG-TDM	JED III	10	923	no false	no false	no false			
	IAG- future	JED III	10	926.25	no false	no false	no false			
5G HH-Tag	IAG-TDM	JED III	5	904.5	no false	no false	no false			
	IAG- future	JED III	5	907.75	no false	no false	no false			

5. OTHER READERS

Various other tolling readers were also tested using the same bench setup for interference tolerance. Note that the distance estimates will have significant variations due to local conditions.

5.1 3M reader

The base station and handset interference to the 3M reader (like Neology reader) was measured and is reported below. The closest frequency available was 911.25 MHz with this model of reader firmware.

Rdr	3M Reader Tag Protocol	Reader /Tag Freq MHz	Baseline Reader RX level + 3 dB, no 5G	Sign Gen Freq edge, MHz	Offset from edge	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
	5G Base to Reader							
3M	SeGo	915.75	-44.4	918	2.25	-6	-4	0
3M	6C	915.75	-40.4	918	2.25	-13		-8
3M	IAG	915.75	-56.9	918	2.25	-18	-14	-10
3M	IAG- future	915.75	-56.9	921.25	5.5	-16	-12	-8
	5G UE Handheld to Reader							
3M	SeGo	911.25*	-62.4	907	2.25	-7		-2
3M	6C	911.25*	-41.4	907	2.25	-13	-11	-9
3M	IAG	915.75	-56.9	907	8.75	-16	-13	-10
3M	IAG- future	915.75	-56.9	910.25	5.5	-14	-11	-9
		*reader switched from 909.25 to 911.25 FCC sub-band limit with 5G handset still 902-907						

The distance separation required to prevent the worst case 5G interference based upon the above 90% handshake level of normal is shown below for the 3M reader

3M Reader Tag Protocol	Reader /Tag Freq MHz	Worst 5G Intf Watts	Worst 5G Intf dBm	Tag Sens dBm 90%	worst case dB PL	UMa- LOS meters	RMA- LOS meters	UMI- LOS meters	InH LOS m	Free Space PL m
5G Base to Reader										
SeGo	915.75	20,000	73	-6	79	225	212	180		233
6C	915.75	20,000	73	-13	86	469	452	388		521
IAG	915.75	20,000	73	-18	91	792	757	672		926
5G UE Handheld to Reader										
SeGo	911.25*	0.193	22.85	-7	29.9				<1	
6C	911.25*	0.193	22.85	-13	35.9				<1	
IAG	915.75	0.193	22.85	-16	38.9				<1	

*reader switched from 909.25 to 911.25 with 5G handset still 902-907 MHz

5.2 Kapsch Janus Reader

The base station and handset interference to the Janus Kapsch reader is reported below, where the closest available frequency of 910 MHz was used in this certified model.

Reader	Tag Protocol	Reader /Tag Freq MHz	Baseline Reader RX level + 3 dB, no 5G	Sign Gen Freq edge, MHz	Offset from edge	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
	5G Base to Reader							
Janus	SeGo	915.75	-50.4	918	2.25	-13	-12	-8
Janus	6C	915.75	-47.4	918	2.25	-17	-15	-9
Janus	IAG	915.75	-59.9	918	2.25	-70		-67
Janus	IAG- future	915.75	-59.9	921.25	5.5	-64	-61	-59
	5G UE handheld to Reader							
Janus	SeGo	909.25	-48.4	907	2.25	-13		-10
Janus	6C	910*	-47.4	907	2.25	-19	-17	-14
Janus	IAG	915.75	-59.9	907	8.75	-33	-30	-27
Janus	IAG- future	915.75	-59.9	910.25	5.5	-65		-60
		*reader switched from 909.25 to 910 FCC sub-band limit with 5G handset still 902-907						

The distance separation required to prevent the worst case 5G interference based upon the above 90% handshake level from normal is shown below for the Janus Reader, where the TDM keep away distance is also computed in Non-Line-of-Sight due to the large dB protection range of the older Janus 2.3 RF module as shown below:

Reader	Tag Protocol	Reader /Tag Freq MHz	Worst 5G Intf Watts	Worst 5G Intf dBm	Rdr Sens dBm 90%	worst case dB PL	UMa- LOS meters	RMA- LOS meters	RMA- NLOS meters	UMI- LOS meters	FSPL meters
	5G Base to Reader										
Janus	SeGo	915.75	20,000	73	-13	86	469	452	n.a.	388	521
Janus	6C	915.75	20,000	73	-17	90	713	685	n.a.	602	825
Janus	IAG	915.75	20,000	73	-70	143	>>5K	>>5K	5892	>>5K	n.a.
	5G UE handheld to Rdr										
Janus	SeGo	909.25	0.193	22.85	-13	36					2
Janus	6C	910*	0.193	22.85	-19	42					3
Janus	IAG	915.75	0.193	22.85	-33	56					16
		*reader switched from 909.25 to 910									

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5.3 Star

The base station and handset interference to the Star reader is reported below. The frequency could not be set to 909.25 with the current certified model, so 910.75 MHz used:

Rdr	Tag Protocol	Reader /Tag Freq MHz	Baseline Reader RX level + 3 dB, no 5G	Sig Gen Freq edge, MHz	Offset from edge	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
	5G Base to Reader							
Star	SeGo	915.75	-51.4	918	2.25	-6	-4	
Star	6C	915.75	-47.4	918	2.25	-3		
Star	IAG	915.75	-41.9	918	2.25	-18	-13	-10
Star	IAG- future	915.75	-41.9	921.25	5.5	Maxed out, no effect		
	5G UE handheld to Reader							
Star	SeGo	909.25	-51.4	907	2.25	Maxed out, no effect		
Star	6C	910.75*	-47.4	907	2.25	Maxed out, no effect		
Star	IAG	915.75	-41.9	907	8.75	Maxed out, no effect		
Star	IAG- future	915.75	-41.9	910.25	5.5	-2		
		*reader switched from 909.25 to 910.75 FCC sub-band limit with 5G Handset still at 902-907 MHz						

The distance separation required to prevent the worst case 5G interference based upon the above 90% handshake level from normal is shown below for the Star Reader:

Rdr	Tag Protocol	Reader /Tag Freq MHz	Worst 5G Intf Watts	Worst 5G Intf dBm	Reader Sens dBm 90%	worst case dB PL	UMa-LOS meters	RMA-LOS meters	UMI-LOS meters	FSPL meters
	5G Base to Reader									
Star	SeGo	915.75	20,000	73	-6	79	225	212	179	233
Star	6C	915.75	20,000	73	-3	76	164	152	128	165
Star	IAG	915.75	20,000	73	-18	91	792	758	602	926
	5G UE handheld -Reader									
Star	SeGo	909.25			no effect					
Star	6C	910.75*			no effect					
Star	IAG	915.75			no effect					
			*reader switched from 909.25 to 910							

5.4 TransCore Rail ATA AI-1200 with AR-2200 RF module

TransCore's ATA tag protocol is used in hundreds of rail sites around the country. While some of these sites may be upgraded in the future, many may continue to be used for another decade or more. Thus, testing is done with the older readers model AI-1200 with AR-2200 RF module.

The readers tested were crystal controlled and could not be shifted in frequency, therefore testing was within passband as highlighted in yellow for some cases. Additional testing planned for other frequency differences by shifting the signal generator.

The impact of trying to operate within the 5G band is shown in the tables below – reader is much less tolerant of on-frequency interference, be it from the base station or handheld

AI-1200 Reader RF Module	Tag Protocol	Rdr/Tag Freq MHz	Baseline Reader RX level + 3 dB, no 5G	Sign Gen Freq edge, MHz	Offset from edge MHz	Level for 90% HS	Level causing 50% HS	Level causing Miss or 5% HS
5G Base to Reader								
2200	ATA	903	-65.4	918	15	-21	-20	-19
2200	ATA	918.5	-66.4	918	within 5G	-49	-48	-47
5G UE handheld to Reader								
2200	ATA	903	-65.4	907	Within 5G	-66	-65	-63
2200	ATA	918.5	-66.4	907	-11.5	-18	-17	-16

The distance separation required to prevent the worst case 5G interference based upon the above 90% handshake level from normal is shown below for the ATA AI-1200 Reader with the AR-2200 RF module: Values in yellow are for reader frequencies that are inside the 5G Downlink or Uplink passbands since only crystal controlled RF modules on those frequencies were available during testing.

AI-1200 Reader RF Module	Tag Protocol	Reader /Tag Freq MHz	Worst 5G Intf Watts	Worst 5G Intf dBm	Reader Sens dBm 90%	worst case dB PL	UMa- LOS meters	RMA- LOS meters	UMI- LOS meters	FSPL meters
5G Base to Reader										
2200	ATA	903	20,000	73	-21	94	1084	933	934	1308
2200	ATA	918.5	20,000	73	-49	122	in-band			
5G UE handheld to Reader										
2200	ATA	903	0.193	22.85	-66	88.85	in-band			
2200	ATA	918.5	0.193	22.85	-18	40.85				3

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6. CONCLUSIONS

Background

NextNav has petitioned the FCC under proceeding 24-240, with additional FCC considerations of PNT (Position, Navigation and Timing) complementary and alternative technologies to GPS under proceeding 25-110. NextNav proposes using 5G NR (New Radio) waveforms and signals as currently used in cellular applications over the following frequency ranges:

- A. Base Stations 918 to 928 MHz
- B. Upgraded Cellphone Handheld and other user equipment 902 to 907 MHz

In addition to the following signal levels of:

- A. Base Station antenna effective radiated power (ERP) allowed up to 1,000 watts/MHz in urban areas and 2,000 watts/MHz in rural installations, which means up to 10,000 watts in urban and 20,000 watts in rural over the 10 MHz band proposed
- B. Handsets up to 3 watts ERP

The NextNav petition requested a change to the multilateration rules as implemented, allowing more power, and moving their sub-band down into the allocated band for RFID based systems impacting existing products and many licensed sites.

Current tolling systems utilize 902-904 and 909.75–921.75 MHz LN with multiprotocol readers/antenna placed across multi-lanes and near each other. High read reliability (99.98% or better) is operationally required, and to achieve this careful frequency, power levels, interference and timing must be optimized.

Testing

TransCore conducted testing to assess how the proposed NextNav 5G PNT system, operating in an expanded adjacent spectrum, may interfere with readers and tags used in national interoperable tolling systems. The evaluation covered the National Interoperability protocols of TDM, SeGo, and 6C on both tags and readers. Testing followed established tolling industry procedures developed in coordination with E-ZPass and IBTTA representatives.

Both lab and lane results show that 5G signals from the base stations and handsets can significantly degrade tolling system performance, with the degree of degradation, varying per protocol. Interference was observed in all modes tested and included impacts to the tag, reader, and the system level tag to reader handshakes. These effects can reduce or prevent tag reading entirely. In addition, the proposed 5G signals from the base station extend to multi-mile distances for some protocols, while handset interference was measurable at tens of feet and may affect tags inside vehicles and readers over the roadway. The severity of interference is influenced by typical system gains and losses, reflections from vehicles and roadside infrastructure, as well as the variation in peak to average 5G signals. Even small bit errors can disrupt tag-to-reader communication because some protocols rely on single frame responses. The interference levels vary across protocols, reader types, and environmental conditions.

Conclusions:

Test result conclusions, based upon the testing methodology and procedures developed in coordination with the IAG and IBTTA representatives, are the following:

- Change in bandwidth will impact reader software/firmware
- Change in bandwidth may impact reader hardware and/or require additional hardware in the plaza
- Reduction in allocated bandwidth may impact system performance due to inadequate frequency channel spacing
- RF susceptibility to 5G signals depends upon reader, frequencies, protocols, timing, duty cycle and path losses incurred at the plaza
- Reduced life in battery powered tags from false triggering
- Distance required to mitigate possible interference in the system is many meters to kilometers depending upon protocols and specific situations

Tag Interference exists for all protocols but worse for more sensitive tags. The specified mid-point in sensitivity is approximately -15.8 (6c), -12 (TDM) and -10.5 (SeGo). More specifically, lab measurements on multiple samples of tags in each protocol indicate the following and are shown in the following tables:

NEXTRAV 5G NR INTERFERENCE TOLERANCE TESTING TO E6 & OTHER READERS & TAGS

- 6c tags are on average 2-3 dB more sensitive than TDM tags and 4-5 dB more sensitive than SeGo tags. Therefore, the median 6C tag will require the most stand-off distance, i.e. the interfering signal transmission must be further away to avoid a negative performance impact.
- TDM tags are on average 3–4 dB more sensitive than SeGo tags and 2-3 dB less sensitive than 6c tags. Therefore, the median TDM tags require an increase in stand-off distance compared to SeGo tags, but less than 6c tags. Note: TDM tags are active and have a filter, so the interfering frequency has a major impact on susceptibility.
- SeGo tags are on average 4–5 dB less sensitive than 6c tags and 2-3 dB less sensitive than TDM tags. Therefore, the SeGo Tags require the smallest increase in stand-off distance compared to 6c and TDM tags.

Note: Maximum power of 20,000 Watts or 73dbm in rural areas has a 7db increase in distance required.

The following tables depict interference (intf), tag sensitivity, based on Urban Macro (IMa), Rural Macro (RMa), Urban Micro (Imi), and Free-Space Path Loss (FSPL) loss models.

5G Interferer Base to tag	5G Intf (Watts)	5G Intf (dBm)	Tag Type	Tag Sensitivity (dBmi)	Loss Model UMa-LOS meters	Loss Model RMa-LOS meters	Loss Model UMi-LOS meters	Loss Model FSPL meters
Typical	3,890	66	6c	-15	319	618	292	736
Typical	3,890	66	SeGo	-10	167	187	152	205
Typical	3,890	66	TDM	-13	189	236	172	261

- Reader Interference exists for all protocols but much worse for TDM shown in the following table.

The following tables depict interference (intf), reader sensitivity, based on an Urban Macro (IMa), Rural Macro (RMa), Urban Micro (Imi), and Free-Space Path Loss (FSPL) loss models.

5G Interferer Base to E6	5G Intf (Watts)	5G Intf (dBm)	Tag In Box (TIB)	Reader Sensitivity +3dB (dbm)	Loss Model UMa-LOS meters	Loss Model RMa-LOS meters	Loss Model Umi-LOS meters	Loss Model FSPL meters
Typical	3,890	65.90	6c	-47.40	139	126	109	137
Typical	3,890	65.90	SeGo	-54.40	100	88	78	97
Typical	3,890	65.90	TDM	-58.00	>5K	7,061	>5K	98K
5G Interferer Handset to E6	5G Intf (Watts)	5G Intf (dBm)	TIB	Reader Sensitivity +3dB (dbm)	Loss Model UMa-LOS meters	Loss Model RMa-LOS meters	Loss Model Tag INH-LOS meters	Loss Model FSPL meters
Typical	0.061	17.85	6c	-47.40	n/a	n/a	<1	2.18
Typical	0.061	17.85	SeGo	-54.40	n/a	n/a	<1	1.64



June 3, 2026

The Honorable Richard Hudson
Chairman
2125 Rayburn House Office Building
Washington, D.C. 20515

The Honorable Doris Matsui
Ranking Member
2323 Rayburn House Office Building
Washington, D.C. 20515

Re: Correspondence for inclusion in the record for June 4, 2026 Communications
& Technology Subcommittee hearing

For your consideration, please find attached a letter from Edison International President and Chief Executive Officer Pedro Pizarro, addressed to Secretary of Commerce Howard Lutnick, outlining Edison International's concerns regarding NextNav's FCC petition requesting use of the lower 900 MHz band. Allowing this petition to proceed would cause unacceptable interference with utility and public safety operations and would impose unnecessary and duplicative costs on our customers. These impacts are not unique to Edison International and would be felt by utility customers nationwide.

Edison International appreciates the Committee's attention to this important issue and the recent hearing on the need for a robust PNT system. However, permitting NextNav to build out operations in the lower 900 MHz band would cause significant harm to incumbent operators in the band.

Sincerely,

Cc:

The Honorable Brett Guthrie, Chairman
The Honorable Frank Pallone, Ranking Member



Pedro J. Pizarro
President &
Chief Executive Officer

May 4, 2026

The Honorable Howard Lutnick
Secretary of Commerce
U.S. Department of Commerce
1401 Constitution Avenue NW
Washington, DC 20230

Dear Secretary Lutnick,

On behalf of Southern California Edison (SCE), a subsidiary of Edison International, I am writing to share our significant concerns regarding the NextNav lower 900 MHz Petition for Rulemaking currently before the Federal Communications Commission (FCC), and to respectfully request that you oppose this petition.

Allowing NextNav to reconfigure the 902-928 MHz band would create unacceptable interference with millions of SCE devices, posing serious risks to public safety, utility operations and the millions of customers and businesses that rely on our electric system.

SCE is one of the largest electric utilities in the nation, serving approximately 15 million people across a 50,000-square-mile service area within Central, Coastal and Southern California, encompassing more than 180 incorporated cities and 15 counties. SCE operates approximately 125,000 miles of distribution and bulk transmission infrastructure, and it is likely that SCE is the largest user of the lower 900 MHz band within our Southern California service and generation area.

The petition before the FCC presents substantial operational risks to the utility. SCE relies on the lower 900 MHz band to support both its smart meter network and its Netcomm Operations Distribution Automation system. SCE operates more than 5 million smart meters that provide continuous, real-time data on customer electricity usage and enable critical safety functions, including the detection of energized downed-wire events. Interference with these communications could impair SCE's ability to promptly identify and respond to serious safety hazards.

The Netcomm network provides SCE with remote access to its distribution system, enabling efficient adjustment of grid-protection settings during periods of elevated wildfire risk. This capability is essential to balancing safe and reliable electric service with rapidly evolving operating conditions. Any interference affecting this system would require the physical deployment of field personnel to manually operate equipment, significantly diminishing SCE's operational effectiveness. Given that much of SCE's high-risk infrastructure is located in rural areas, such interference would increase employee and public safety risks and could prolong customer outages.

At a time when the Administration is appropriately focused on energy affordability for consumers, this proposal would also impose significant switching costs on utility operations that could ultimately affect customer rates. These impacts are not unique to Southern California, as electric utilities across the country similarly rely on the lower 900 MHz band. Nationwide switching costs could reach into the billions of dollars.

P.O. Box 976
2244 Walnut Grove Ave.
Rosemead, CA 91770



Pedro J. Pizarro
President &
Chief Executive Officer

The Honorable Howard Lutnick
May 4, 2026
Page 2

We appreciate the FCC's efforts to strengthen Global Positioning System (GPS) resilience through this Petition for Rulemaking. However, those efforts should not come at the expense of safe and reliable electric service or the many critical-infrastructure sectors that depend on this spectrum. Given the importance of this matter, I respectfully urge the Department of Commerce and the National Telecommunications and Information Administration (NTIA) to oppose the NextNav petition.

Thank you for your consideration. I look forward to continued engagement on this important issue.

Sincerely,

A handwritten signature in blue ink, reading "Pedro J. Pizarro".

Pedro J. Pizarro
President and Chief Executive Officer
Edison International

George C. Landrith
President & CEO



Senator Malcolm Wallop
(1933 - 2011)
Founder

June 3, 2026

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Office of Congressman Frank Pallone
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Office of Congressman Brett Guthrie
2161 Rayburn House Office Building
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Office of Congresswoman Doris Matsui
2206 Rayburn House Office Building
Washington, D.C. 20515

Dear Chairman Rep. Guthrie, Chairman Rep. Hudson, Ranking Member Rep. Pallone,
and Ranking Member Rep. Matsui:

On behalf of the Frontiers of Freedom Institute, I write to urge Congress to support efforts to strengthen America's Positioning, Navigation, and Timing (PNT) resilience and to oppose attempts to impede the Federal Communications Commission's ongoing review of technologies that can provide backup and complementary capabilities to GPS.

The issue before Congress is straightforward: GPS has become a critical component of America's economic, transportation, communications, financial, and national security infrastructure. Yet it is increasingly vulnerable to disruption, interference, jamming, and spoofing by foreign adversaries.

The threat is neither theoretical nor distant.

More than 430,000 GPS jamming and spoofing incidents were reported worldwide in 2024, affecting as many as 1,350 flights per day and representing a dramatic increase over the previous year. Interference has already been detected near major American airports, including Dallas and Denver. Analysts estimate that a significant GPS outage could cost the U.S. economy approximately \$1.6 billion per day while disrupting transportation, communications, finance, and public safety systems.

At the same time, America's principal adversaries continue to expand their capabilities in electronic warfare and space operations. China and Russia have demonstrated increasingly sophisticated abilities to interfere with satellite-based systems and have openly pursued capabilities designed to challenge U.S. technological superiority.

This should concern every American.

GPS has become so deeply integrated into modern life that many people no longer recognize how dependent we have become upon it. Aviation, maritime commerce, trucking, rail transportation, telecommunications networks, financial transactions, electrical grids, precision agriculture, and countless commercial applications rely upon accurate positioning and timing signals.

Public safety systems are especially vulnerable. First responders rely on GPS-enabled technologies to locate emergency callers, route ambulances, coordinate disaster response, and conduct search-and-rescue operations. Emergency communications systems depend upon precise timing signals to function effectively. A prolonged disruption would have consequences that extend far beyond inconvenience; it could directly affect the ability of emergency personnel to protect lives and property.

Fortunately, both the Trump Administration and the FCC have recognized the urgency of this challenge.

President Trump has emphasized the importance of strengthening America's resilience and reducing vulnerabilities in critical infrastructure. FCC Chairman Brendan Carr has likewise identified GPS dependence as a potential single point of failure and has initiated a proceeding to examine complementary and backup technologies capable of enhancing national resilience.

This is precisely the type of process that should be encouraged.

The FCC's proceeding does not predetermine a winner. It does not dictate a particular technology. Rather, it seeks to evaluate available options and determine how America can develop a robust "system of systems" approach that reduces dependence on any single technology or platform.

That is a prudent and responsible course of action.

Unfortunately, recent efforts to prohibit the FCC from using appropriated funds to continue this proceeding would move the country in the wrong direction.

Regardless of one's views regarding any particular technology or commercial provider, Congress should not substitute political judgments for technical analysis before the facts have been fully developed. Using an appropriations rider to terminate a technical proceeding risks delaying solutions to a vulnerability that national security experts, industry leaders, and policymakers increasingly recognize as urgent.

America's adversaries are not waiting for us to resolve procedural disputes. They are actively developing capabilities designed to exploit vulnerabilities in our systems.

Congress should therefore allow the FCC process to continue and permit experts to evaluate the full range of available technologies and solutions.

Importantly, the encouraging news is that potential solutions already exist. American innovators have developed technologies capable of providing complementary positioning, navigation, and timing services through terrestrial infrastructure using existing assets and licensed spectrum. Some estimates place the economic value of a resilient GPS backup capability at more than \$14 billion, while much of the necessary investment can be provided through private-sector capital rather than taxpayer funding.

This is exactly the kind of challenge America should be eager to solve.

The United States has long led the world by combining innovation, private enterprise, technological excellence, and strong public policy. Building greater resilience into our positioning, navigation, and timing infrastructure should be viewed through that same lens.

This is not a partisan issue.

Republicans and Democrats alike depend upon reliable transportation systems, resilient communications networks, secure financial markets, and effective emergency response capabilities. Every American benefits when critical infrastructure is more secure and less vulnerable to disruption by foreign adversaries.

Congress should support the Administration's efforts to strengthen national resilience, allow the FCC's technical review to proceed without interference, and encourage the development of market-based solutions that enhance America's security and competitiveness.

The risks are real. The vulnerabilities are known. The technologies are emerging.

Now is the time to strengthen America's resilience before a major disruption forces us to learn these lessons the hard way.

Sincerely,



George Landrith
President, Frontiers of Freedom Institute

June 4, 2026

The Honorable Brett Guthrie
Chairman, Committee on Energy and
Commerce
U.S. House of Representatives
2161 Rayburn House Office Building
Washington, DC 20515

The Honorable Frank Pallone, Jr.
Ranking Member, Committee on Energy
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The Honorable Richard Hudson
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The Honorable Doris Matsui
Ranking Member, Subcommittee on
Communications and Technology
U.S. House of Representatives
2206 Rayburn House Office Building
Washington, DC 20515

Dear Chairman Guthrie, Ranking Member Pallone, Chairman Hudson, Ranking Member Matsui,
and Distinguished Members of the Subcommittee on Communications and Technology:

I write regarding the June 4, 2026, House Energy and Commerce Committee,
Subcommittee on Communications and Technology hearing, "Where Are We?: Examining
Positioning, Navigation, and Timing Capabilities in the United States."

The Subcommittee should take seriously the need for the United States to pursue
strategies and technologies that sustain, strengthen and reinforce GPS capabilities. At the same
time, I strongly urge the Committee to carefully scrutinize and reject proposed solutions that
otherwise undermine the critical economic, communications, transportation, public safety, and
national security systems already in place across the United States.

As a military officer and later as Commander of the U.S. Air Force Space Command, I have
seen the extraordinary power of GPS and its potential vulnerabilities. I agree wholeheartedly
with the premise of this hearing: that the United States is dangerously overdependent on a single,
space-based Positioning, Navigation, and Timing (PNT) signal, and that vulnerability demands
urgent action. For years, the federal government has recognized the need for resilient PNT
infrastructure. The National Space-based Positioning, Navigation, and Timing Advisory Board has
highlighted this for many years.

A member of the National Security Council has rightly described GPS as a "single point of
failure" for the nation. Russia and China have demonstrated the capacity and the intent to exploit
exactly that weakness. Recent conflicts further underscore this risk: there was widespread GPS
jamming during operations in Venezuela—likely involving Chinese-manufactured systems—as
well as extensive jamming during Russia's invasion of Ukraine and in U.S. and Israeli operations

involving Iran, where the jamming systems were likely Russian-built. The risk is real, and the United States must address alternatives to GPS with a serious, scalable solution.

A true backup must incorporate diverse, independent sources—such as terrestrial broadcasts, fiber-based timing, and alternative satellite networks—to ensure redundancy and resilience. Unfortunately, a proposal by NextNav before the Federal Communications Commission (FCC) fails to meet this standard.

NextNav's proposal would not resolve America's positioning, navigation, and timing vulnerabilities. Instead, it would merely replace one fragile dependency with another, while creating significant collateral consequences in the process. A proprietary, single-company terrestrial system dependent on one frequency band is just as susceptible to targeted disruption as the GPS it purports to back up. Genuine resilience requires diversity of signal origin, diversity of infrastructure, and diversity of technology. NextNav's proposal delivers none of that.

Specifically, NextNav is asking the FCC to fundamentally reconfigure the 902-928 MHz band, dramatically expand its spectrum rights, and weaken or eliminate longstanding interference protections that hundreds of millions of unlicensed devices have relied upon for more than three decades. These devices support critical functions across the U.S. economy, including industrial IoT systems, public safety communications, medical technologies, precision agriculture, utilities, transportation, and security infrastructure.

In exchange, NextNav promises a future 5G-based terrestrial PNT system that does not yet exist in deployable form, has no enforceable buildout timeline, and would still leave significant gaps in rural, mountainous, and maritime coverage where quadruple base-station density is simply not achievable.

What is striking is how broad the opposition to this proposal has become. Public safety organizations, the aviation industry, the security industry, utilities, wireless ISPs, toll operators, and consumer technology groups have all filed strong objections at the FCC. The record of interference risk has been documented by multiple independent technical studies, and the Subcommittee should ask NextNav directly why virtually every other stakeholder operating in or adjacent to the 900 MHz band opposes the company's petition.

I support building a layered, terrestrial complement to GPS, and multiple capable alternatives either already exist or are rapidly maturing, including broadcast-based systems, eLoran and emerging commercial LEO constellations. The FCC's inquiry process exists precisely to evaluate these technologies and approaches on their merits, and Congress should reinforce that posture. The FCC should not address this issue in isolation, particularly when its decisions could have sweeping, long-term consequences for spectrum users, critical infrastructure operators, and the broader U.S. economy.

Congress should consider designating a lead federal agency to coordinate a comprehensive interagency review and competitive evaluation process for resilient PNT

solutions. Such an approach would help ensure that the United States pursues the most effective, scalable, and secure technologies while protecting existing spectrum-dependent systems that are already essential to commerce, public safety, innovation, and national security.

Given America's deep dependence on GPS, the United States cannot afford shortcuts when strengthening PNT resilience and security. Growing threats from foreign adversaries demand a deliberate, layered, and carefully coordinated approach. A competitive, technology-neutral framework will help ensure the United States develops the resilient PNT infrastructure it truly needs to support economic security, public safety, and national defense. Anything less risks creating new vulnerabilities while failing to adequately address existing ones.

Respectfully submitted,

A handwritten signature in black ink, appearing to read "William L. Shelton". The signature is fluid and cursive, with a prominent "W" and "S".

General William L. Shelton (USAF, Ret.)
Former Commander, Air Force Space Command

**KAPSCH TRAFFICCOM REPORT OF LABORATORY TESTING AND IMPACT ANALYSIS
FOR KAPSCH NM-LMS PRODUCT AGAINST INTERFERENCE FROM NEXTNAV
PROPOSED USAGE OF THE LMS SPECTRUM**

PRODUCT: KAPSCH UHF AVI PRODUCTS

DOCUMENT NUMBER: TN 360100-038

REVISION: A

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Kapsch TrafficCom Report of Laboratory Testing and Impact Analysis for Kapsch NM-LMS Product against Interference from
NextNav Proposed Usage of the LMS Spectrum

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1. INTRODUCTION

1.1 Scope

This document records and analyzes the test results measured when testing the certified Kapsch TrafficCom (“Kapsch”) UHF readers and transponders, used for Automatic Vehicle Identification (AVI) including Electronic Toll Collection (ETC) and Commercial Vehicle Operations (CVO), for susceptibility in a laboratory environment against the interference that could be generated by 5G networks deployed in the 902-928 MHz Location and Monitoring Service (LMS) spectrum controlled under 47 CFR90 [AD1] ¹ as a result of the proposed changes petitioned to the Federal Communications Commission (FCC) by NextNav Inc. (“NextNav”).

In April 2024 NextNav submitted a petition [RD1] to the FCC to fundamentally change the use of the 902-928 MHz LMS spectrum, including revising the sub-band frequencies and allocations. Subsequently in June 2024 they also submitted [RD2] their proposed rule changes to the sections of 47CFR [AD1] related to that spectrum. Note that in addition to location and monitoring services, the 902-928 MHz spectrum is also allocated by the FCC for other applications, in particular for unlicensed users under 47CFR15 [AD2]. The current LMS frequency band is separated into multilateration LMS (M-LMS), the LS radio service, and non-multilateration (NM-LMS), the LN Radio Service sub-bands. AVI functions are performed using the NM-LMS sub-bands, and it is to frequencies in these sub-bands that Kapsch equipment is certified.

In those proposed rules NextNav have revised the division of the band into 3 sub-bands with NM-LMS being shifted to a single **smaller** sub-band of 907-918 MHz. **without guard bands**, and the remaining 2 sub-bands defined in the rules as a “Terrestrial Positioning, Navigation, and Timing” (TPNT) service. Since the majority of the capacity will be for general wireless communications, Kapsch is using the term LMS-5G to represent the services that could result in this band from the proposed rule changes. Further since the proposal is intending to change the sub-band allocations for NM-LMS, the proposed revised allocations for the current NM-LMS are named NM-LMS-Prop herein, to avoid confusion between existing and proposed. Figure 1 shows the NextNav proposed frequency plan incorporating these identities.

In August 2024 the Wireless Communications Bureau (WTB) and Office of Engineering and Technology (OET) sought comment [RD3] on the NextNav petition. The WTB docket 24-240 was assigned for all correspondence with the FCC on the petition by NextNav.

Because of the widespread usage of this frequency band, many parties have filed opposition comments to the NextNav petition. In particular for ETC and CVO operations, E-ZPass², the PrePass Safety Alliance³ and the International Bridge, Tunnel and Turnpike Association (IBTTA)⁴, have filed opposition comments, which include inputs from the AVI and CVO vendors, to the NextNav proposal in response to the petition as well as to subsequent NextNav submissions to the WTB under the docket.

Kapsch and other vendors, and their customers, who use this band for AVI applications, both licensed and unlicensed applications, have significant concerns about the impact that LMS-5G networks deployed under the proposed rules can have on ETC and CVO operations. Further there has been no analysis from NextNav showing the reciprocal impact that ETC and CVO operations will have on the LMS-5G operations.

¹ [ADx] and [RDx] are identifiers of applicable and reference documents respectively and the full document identification is provided in section 3.1

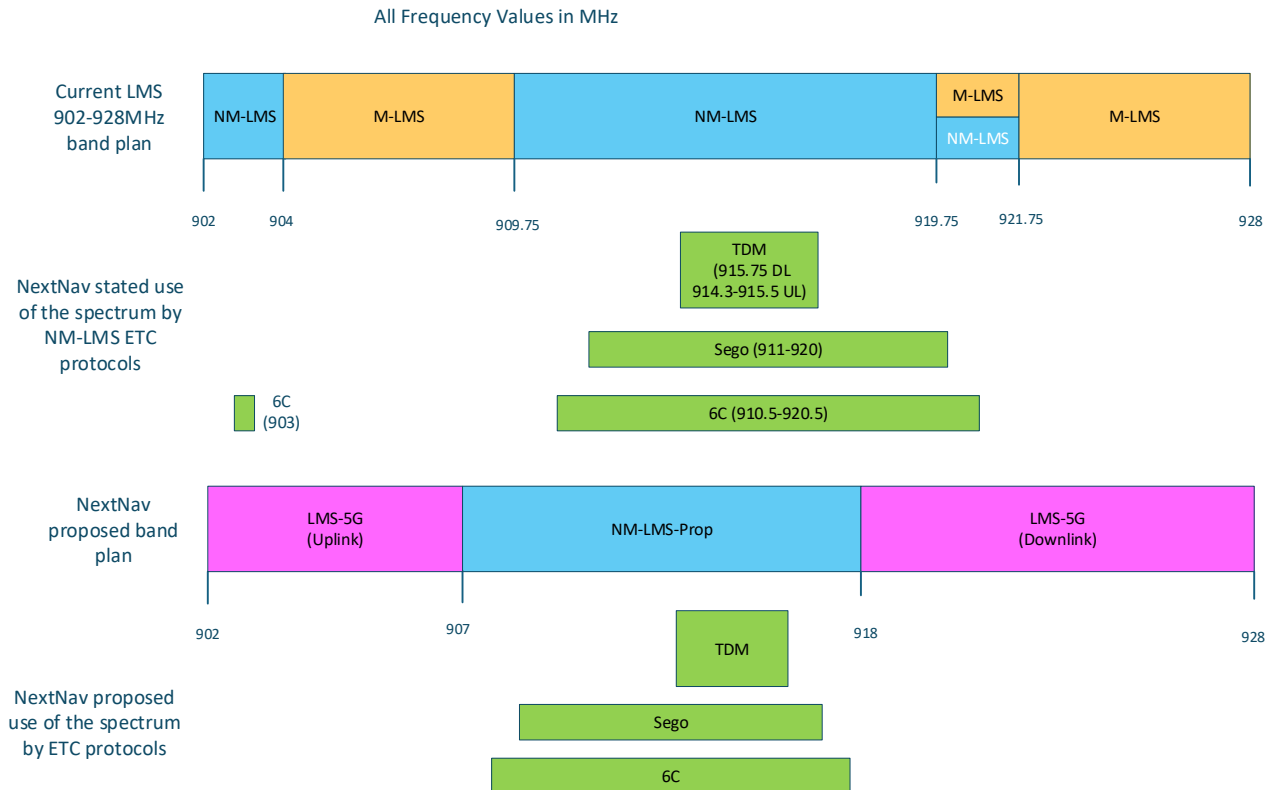
² E-ZPass refers to the Interagency Group consisting of member toll agencies/companies in 20 states which operate ETC systems used on toll roads, toll bridges, and toll tunnels in the eastern half of the United States, and other applications using the same ETC equipment.

³ The PrePass Safety Alliance is a non-profit corporation focused on commercial transportation safety, and operates in conjunction with states the track safety pre-clearance system, also referred to herein as weigh-station bypass.

⁴ The IBTTA is a worldwide alliance of toll facility operators and associated industries.

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Figure 1: Frequency Plan Showing NextNav Proposed Frequency Changes



Note the figure has been amended from the figure provided by NextNav to reflect the naming of the new sub-bands to avoid confusion, and clarification of the current center frequency ranges.

Note also the frequency ranges refer only to the center frequencies of the protocol transmissions.

While the AVI vendors have supported E-ZPass in attempting to establish a joint test plan with NextNav, agreement was not reached with NextNav. NextNav have since submitted their own coexistence study [RD7] on the LMS-5G impact to ETC use. However that study is deemed inadequate and flawed and comments have been filed exposing issues with that study including [RD8, RD10]. While NextNav have filed a response [RD16] to these comments, no conclusion can be reached yet on the subject of coexistence. This study exposes some additional issues with those NextNav studies and NextNav assertions with respect to the impacts of the spectrum change.

In an effort to provide the FCC with objective test data that exposes the risks to AVI operations, the key AVI vendors, in cooperation with E-ZPass and the IBTTA, have or are conducting laboratory tests (Neology in [RD10], others in process) to evaluate the susceptibility of their current AVI equipment to networks deployed under the proposed rules. This testing was a continuation of the joint test plan that was previously being discussed with NextNav.

This report covers the susceptibility testing by Kapsch in support of that objective for the 3 primary ETC protocols, TDM, 6C and SeGo, as well as the CVO protocol ASTMv6 a.k.a. TDMA.

The test results record the line of sight free-space boresight susceptibility against LMS-5G signals of the Kapsch NM-LMS products that utilize this spectrum and based on these measurements, analysis is carried out to compute a first order level of coexistence assessment to see if there is any possibility of coexistence issues – something NextNav has stated is not possible.

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This first-stage coexistence analysis is intended to indicate either coexistence coordination between LMS-5G and AVI systems is not required, which is what NextNav asserts, or if more detailed assessment is needed to determine the level of risk and if coexistence coordination is required. The results indicated that coexistence issues are probable even if NM-LMS equipment is updated to improve susceptibility and coordination is likely required.

As well, the first-stage analysis serves to provide information that can be used to determine the appropriate field testing that would be required to properly establish coexistence risk and where equipment improvements may be needed to facilitate coexistence.

Where the first stage analysis indicates coexistence issues are possible, which it did, a second stage of analysis was carried out to evaluate if statistics support the first stage assessment that coexistence risks exist by evaluating the probability of BS-AVI locations sites having such issues, including assuming random relationships between LMS-5G equipment and the AVI equipment and other statistical parameters. The results confirmed that coexistence issues identified by the first stage analysis are valid.

Note this report only covers the susceptibility of the AVI products to LMS-5G signals but does not address the susceptibility to AVI systems of the LMS-5G networks and positioning and timing services that could be deployed under the proposed rule changes. [RD10] includes some initial analysis of the impact of AVI systems on LMS-5G, which is disputed by NextNav in [RD16]. Kapsch believes that it is incumbent on the proponents of the rule change (NextNav) to provide proper analysis and/or testing to the AVI community to show susceptibility of the LMS-5G system both for the general broadband 5G service and for the positioning and timing services to assess the risk to future AVI deployments under the proposed rule changes, before such rules are adopted.

[RD8, RD10] raised a number of test deficiencies and perceived errors in the NextNav tolling coexistence study. This test report includes testing to address some of the identified deficiencies, and discussion of some of those perceived errors. In particular the following deficiencies have been addressed:

- LMS-5G interference impact on performance of readers and transponders from multiple vendors covering their TDM, 6C and SeGo ETC products.
 - [RD10] addressed Neology product.
 - This report extends the results to include Kapsch product.
 - Other NM-LMS ETC vendors will extend the tests to their product
- LMS-5G Impact to TDMA transponders used for both ETC and CVO markets have been included in this report
- LMS-5G Impact to transponders located other than on windshield of vehicles have been included in this report.
- Impacts of ETC emissions of adjacent ETC antennas in multi-lane deployments have been included in this report.
- LMS-5G impact on TDM Write has been included in this report.
- LMS-5G impact on TDM and TDMA transponder battery drain currents which can affect transponder life have been included in this report.

As well, this report addresses the impact the proposed rules have on the Kapsch product frequency plans for NM-LMS ETC and the loss of freedom to move frequencies to avoid local interference, such as from incumbent third parties, especially when that interference is from higher priority Federal Government users of the same band.

2. SUMMARY OF FINDINGS

The test results differ markedly from those of NextNav, confirming that the NextNav results are not representative of the range of ETC products for NM-LMS systems. As well the coexistence analysis results in different conclusions, even for transponder susceptibilities similar to those measured by NextNav.

The analysis indicates there is currently no probability of co-existence with the Kapsch readers unless equipment is replaced in some cases and updated in others. Even if the readers can be updated, there are probabilities of interference issues for transponders that may require site by site coexistence analysis and management.

There are 3 models of Kapsch NM-LMS readers, 1 older generation (MPR2.3) and 2 current (MPR2.4 and MPR4.1). The MPR2.3 and MPR2.4 readers use plug-in radio modules (up to 8 per reader) while the MPR4.1 has a single integrated radio. The plug-in radios comprise the older generation MRFMS, and the current generation MRFMSP. Note that all of these provide the performance needed for ETC and operation under current rules, and the failure rate of reader product is very low such that once readers are deployed they do not normally need to be updated to the latest hardware versions. Currently over 9500 Kapsch radios are deployed in FCC controlled jurisdictions and more are being added as time progresses.

The coexistence results indicate that if coexistence is to be achieved, the MRFMS radios would need to be replaced while the MRFMSP and MPR4.1 would need at least a firmware update to improve susceptibility. Without implementing the change, Kapsch cannot rule out there may also need to be hardware updates to these radios to support the proposed rule changes.

Even with these changes the in lane performance is at risk because the frequency plan of Kapsch readers would need >11 MHz to achieve 4 frequencies and be immune to the LMS-5G system. This also leaves no room for adjusting to other interference present in the LMS band, e.g. higher priority federal users or incumbent users.

There are multiple Kapsch single-protocol windshield transponders covering the TDM, 6C and TDMA protocols. As well Kapsch has a TDM exterior mount transponder that can be used in multiple locations of the vehicle exterior, as well as headlamp mount 6C transponders. There are more than 45 million Kapsch TDM transponders and 1 million Kapsch TDMA transponders that are in warranty, and 20 million Kapsch 6C transponders delivered to FCC controlled jurisdictions, and more are being added as time progresses.

The coexistence results indicates that the Kapsch TDM and TDMA transponder designs would need to be updated to preserve the current life performance, as the battery life would be degraded by the LMS-5G downlink. Also there is definite coexistence risk on the 6C transponders.

In summary the NextNav statements that there is no coexistence risk is not supported by the analysis and it is not just a simple matter of lane retuning if the NextNav proposal is accepted.

2.1 Test Results

Table 2-1 below summarizes the free-space interference susceptibility levels measured on the Kapsch products and compares them to the NextNav stated "representative" data and shows that, as has been stated by others, the NextNav testing and conclusions were based on a limited set of products that can no means be considered representative. The 5% packet error rate (PER) susceptibility level is reported, the same as the conditions reported by NextNav, as well as the 95% PER susceptibility level.

In particular we observe that for the Kapsch readers the TDM protocol is >40 dB more susceptible to the LMS-5G downlink than the level NextNav reported on the reader they tested. Note that the receiver in the Kapsch older generation MRFMS reader radio is similar to the receiver in the readers in use at the time of Progeny testing. The key reason for the TDM susceptibility in the Kapsch readers is that the reader receivers were designed to accept the transponder occupied bandwidth. Note that the reader susceptibility is dependent on interference/transponder signal level and not absolute interference level.

The 6C protocol Kapsch ETC transponders are the most susceptible for any of the 3 primary ETC protocols and the average susceptibility is similar to the NextNav value used, but TDMA transponders are 12 dB more susceptible to the LMS-5G downlink than the value reported by NextNav. The TDM transponder susceptibility does not change with received reader signal power, while all others are dependent of interference/reader signal level.

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The TDM transponder level test results include TDM write performance, while the 6C and SeGo transponder results include the effect of adjacent reader channel frequencies 10 dB below the primary signal.

Table 2-1: Kapsch Products 5% PER Susceptibility Levels at Wake-up vs NextNav Data

Equipment	Protocol and LMS-5G Link Direction	Interference Level dBm(i) For Kapsch product	Interference Level dBm(i) Reported By NextNav	Notes
Reader dBm conducted worst model	TDM DL	-67	-23	MRFMS
	TDM UL	-31	-26	MRFMS
	6C DL	-35 , -20	-40	MRFMSP 1.5 / 2.0 MHz (1)
	6C UL	-33 , -17	-23	MRFMSP 1.5 / 2.0 MHz (1)
	SeGo DL	-11	>-3	MRFMS
	SeGo UL	-15	>-3	MRFMS
Transponders dBm(i) Average of models tested	TDM DL	-14 , -18	>-24	2 nd value is exterior transponders
	TDM UL	-7, >+3		Same for both windshield and headlamp transponders
	6C DL	-24		
	6C UL	-25		
	TDMA DL	-36	Not measured	Only windshield transponders exist
	TDMA UL	-17		

Note (1) – 2 values reported are for different reader carrier frequency offsets from the sub-band edge.

Table 2-2 identifies the LMS-5G interference levels where the current drain from the battery in the TDM and TDMA transponders increases significantly over the normal current levels. Note that unlike the PER results, which only matter when a transponder is at an AVI site, the current drain can occur anywhere the vehicle travels.

Of particular note is the TDMA windshield transponder susceptibility since this is at an interference level significantly lower than NextNav analyzed and the current multiplier is significant at all receive powers above the indicated susceptibility level.

Table 2-2: Kapsch Active Transponder Products Increased Battery Current Susceptibility Levels

Transponder	LMS-5G Link Direction	Average Interference Level dBm(i) for 1.5X normal current	Interference Level dBm(i) at peak current multiplier, and multiplier (1)	Current multiplier at Interference >> peak case
TDM Windshield	DL	-18	-9 for 1000x	23x
	UL	-11	-2 for 1000x	23x
TDM Exterior	DL	-19	-12 for 1000x	23x
	UL	n/a	n/a	n/a
TDMA Windshield	DL	<-31	-31 for 300x	300x
	UL	<-8	-8 for 300x	300x

(1) Eg the entry “-9 for 1000x” means that at -9 dBm(i) the current in the transponder is 1000 times larger than normal current for a transponder outside an AVI site.

Note that these PER and battery current results are only applicable for Kapsch product and should not be interpreted to mean that equipment from other vendors has the same susceptibility levels or current increases.

2.2 Frequency Plan Results

One of the ETC community concerns is that the proposed frequency sub-band changes limit the ability to achieve frequency division multiplex of ETC carrier frequencies at multi-lane sites, or limit the ability to adjust to mitigate local interference present at the site when deploying new sites. Note that the frequency plans are vendor and reader specific.

Kapsch readers utilize 2.5 MHz channel spacing and 4 frequency carriers to meet multi-lane ETC performance. It might seem possible using the Kapsch readers therefore to fit the 4 carriers into the 907-918 MHz but this leaves no margin for avoiding other interference at the toll sites. Further, based on the coexistence analysis, at least 2 MHz guard band separation is required between the reader end carrier frequencies and the sub-band edges to improve immunity to the LMS-5G signals, but this combination then requires at least 11.5 MHz sub-band width.

Also it was observed that the interference will affect all lanes on the site as there was little improvement as channels moved more than 2 MHz away from the sub-band edge, and the fact 3GPP shadow fading will be correlated over larger distance than the toll site.

NextNav stated as recently as August 2025 “*contrary to claims about reducing spectrum available for tolling licensees, tolling operators do not use the 902-904 MHz portion of the band today, and NextNav has no knowledge of their planning to do so.*”⁵ Kapsch is aware of at least one agency that Kapsch supports with licensing that does use this sub band, and requires to do so because of other higher priority users of the band. Specifically the North Carolina Turnpike Authority has a number of ETC sites under call-sign WQJG520 that use this frequency sub-band for 6C and other protocols, and have used it since 2017. Further there are more sites being deployed by that agency that require to use this sub-band for interference management.

Loss of the 902-904 MHz sub-band and restriction in the frequency plans can result in degradations of performance at those sites that experience such other interference.

2.3 Coexistence Analysis Results

NextNav modelled some deployments and using its assumptions and limited measured data they concluded there is no coexistence risk. However there are concerns with the NextNav results, including some listed herein in section 2.5. As well as the disparity in susceptibility levels, shown in Table 2-1 above, provide very different results to those of NextNav’s analysis.

The study shows that in contrast to the NextNav study that there is significant risk to the ETC and CVO operations with currently deployed Kapsch equipment if the NextNav proposal for rule change is accepted. The analysis herein and conclusions are limited to the Kapsch equipment and should not be interpreted to mean that they apply to equipment from other AVI vendors.

There were significant differences between the NextNav reported susceptibility data and the Kapsch device susceptibilities. There are also some disparities on items such as vehicle penetration loss, inclusion of polarization loss and off-axis antenna gain, and in particular the generalization to cover random BS-ETC device relationships, that introduce differences between the co-existence analyses.

The Kapsch analysis identified that all lanes (in a direction) would be affected by the interference to the same degree at the same time since the 3GPP shadow fading correlation distance is much larger than a few lanes of the toll sites. There was little improvement in 6C or SeGo as the carrier frequency was moved through the sub-band, except at the sub-band edge, so channel frequency could not be used to mitigate the LMS-5G interference effects at a site.

Kapsch also assessed that there is reasonable possibility of line of sight between base stations and AVI devices on some toll sites, and that the 3GPP model for the probability of line of site cannot be used when considering multi-lane highway sites.

In this report a statistical approach has been taken for analysis of the co-existence where first stage analysis indicated that there could be risk, and models were developed on key items, so that it is not dependent on using

⁵ Page 2 in cover letter, [RD7] NextNav Tolling Coexistence Study

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assessment of a particular geographic area but instead are generalized to just using the 3GPP and ITU models for assessment.

Note that some assumptions and estimates had to be made to be able to compute the interference risks. For this and other reasons, especially the huge variability due to vehicle-transponder combinations in real-world, that proper coexistence analysis will require field testing, under actual moving vehicle operation and real-world vehicle distributions.

The Kapsch coexistence analysis was first carried out assuming a blanket minimum base-station to ETC site distance of 100 m. If there were no issues beyond this distance then co-existence at ETC sites could be easily managed. Unfortunately this is not the case. In most cases the interference risk peaked in the region 100 m- 300 m from the base station, while the Urban Micro scenario peaked at distances below this.

Kapsch performed modelling in 2 stages. The first stage modelling used LMS-5G and AVI devices pointed at each other in azimuth, but accounting for elevation gain patterns, a typical BS EIRP of 66 dBm, as stated by NextNav and as per Verizon data in the FCC National Broadband Map, and a UE EIRP of 23 dBm as per the same Verizon data. The AVI susceptibility values used the 5% PER data reported in Table 2-1 plus the average of the statistical variables and other loss factors, including polarization - see section 6.2 and Table 6-9. This first stage exposed that there are significant coexistence issues. The result are summarized in Table 2-3.

Table 2-3: Summary of First Stage Modelling Results

Source	Device	Protocol	Key points
BS at typical 66 dBm EIRP d2d min set as 100 m	Reader	TDM	Issues up to 5280 m LOS and 1020 m NLOS Worst 40.9 dB above threshold
		6C	Issues up to 336 m LOS, worst 8.9 dB above threshold No NLOS issues min margin 5.7 dB
		SeGo	No issues, min margin 15.1 dB
	Transponder	TDM	No issues min margin 1.7 dB
		6C	Issues up to 498 m LOS, worst 8.3 dB above threshold No NLOS issues min margin 5.5 dB
		TDMA	Issues up to 1163 m LOS and 270 m NLOS, worst 18.8 dB above threshold
UE at 23 dBm EIRP d2d min set at 0.2 m	Reader	TDM	Issues up to 7.4 m, worst 20.6 dB above threshold
		6C	Issues up to 8.0 m, worst 22.6 dB above threshold
		SeGo	Issues up to 3.0 m, worst 4.6 dB above threshold
	Transponder	TDM	Issues up to 0.3 m, worst 2.3 dB above threshold
		6C	Issues up to 4.0 m, worst 19.3 dB above threshold
		TDMA	Issues up to 1.3 m, worst 11.3 dB above threshold
BS as above d2d min set at 10 m UE as above d2d min set at 0.2 m	Transponder	TDM currents	Issues up to 179 m LOS and 16 m NLOS, worst 8.8 dB above threshold
		TDMA currents	Issues up to 722 m LOS and 89 m NLOS, worst 18.8 dB above threshold
		TDM currents	Issues up to 0.5 m, worst 5.3 dB above threshold
		TDMA currents	Issues up to 0.3 m, worst 2.3 dB above threshold

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Based on the first stage analysis results the following key observations were made if the changes are made to the LMS spectrum and LMS-5G is deployed.

- Based on the Kapsch reader TDM results, Kapsch predicts that the MRFMS radios will need to be replaced and design changes made to the MRFMSP and MPR4.1 radios to substantially improve the TDM performance, if coexistence is to be achieved. Kapsch believes at this time that the MRFMSP changes can be done with only firmware changes and no hardware changes, but cannot confirm this without actually performing the redesign.
- The Kapsch reader 6C results indicate that the carrier to sub-band edge spacing will need to be increased to 2 MHz where only 1.5 MHz is required for emission mask compliance. This places the ability to achieve 4 carriers with 2.5 MHz spacing in the proposed frequency plan at risk, and the KPIs on sites at risk. This also leaves no margin for adjusting due to interference from other sources. Changes may be needed to the MRFMSP and MPR4.1 radio firmware to improve this susceptibility also.
- On the ETC transponder side, the results are in total contrast to the analysis by NextNav. Despite similar measured susceptibility for 6C transponders (-24 dBm(i)), the results herein show susceptibility up to 498 m from the BS in LOS conditions with typical BS EIRP and up to 8 m separation of the windshield transponder from the UE at maximum transmit power.
- TDM transponders which have less susceptibility than reported by NextNav, were not affected by the base stations in the ETC sites, but had low margin. The TDMA transponders definitely were affected and would have to be redesigned to mitigate this.
- In most cases the region 100 m- 300 m from the base station is where the interference issues peak, except for UMi (3GPP street canyon model) where the peak is below 100 m.

The second stage modelling was introduced to identify if statistics support the first stage assessment that coexistence risks exist by evaluating the probability of BS-AVI locations sites having such issues, including assuming random relationships between LMS-5G equipment and the AVI equipment. Note the cell radius is a factor in that probability, but there are no reference data from NextNav on this. FCC National Broadband Map links budgets were used to develop some cell radius values. For BS interference the cases analyzed were sufficient to prove that the first stage analysis is adequate to identify interference risk at the ETC sites. The cases analyzed showed that:

- At 100% DL traffic there is a 8.25% probability that there will be sites where 6C transponders will experience interference above the 5% packet error threshold due to the base station transmissions with a peak of problems at 185 m from the base station. This would therefore imply deployments will require site by site coexistence analysis.
- On the battery current side, both the TDM and especially the TDMA transponders have significant risk of life being reduced by the presence of LMS-5G, and would have to be redesigned to mitigate this.

2.4 Proposed Rules Issues Found

As part of the study, it was identified that there are issues with the proposed rules. Note that these are additive to the issues identified by Kapsch for the rules with respect to certification in a separate submission [RD17]. The following are only those identified during the conduction of this study and should not be interpreted to mean that it is a complete set of issues identified with respect to the proposed rules.

2.4.1 No Positioning Or Timing Requirements In Proposed New Service

NextNav proposes the rule changes be adopted to provide GPS back-up. In support of the GPS back-up claim they indicate certain position accuracies that the system will provide. However, it is observed that other than their proposed naming of the service, nothing in the proposed rules requires the provision of this GPS back-up capability, nor any position or timing accuracy or geographic coverage requirements. While this could be in the Report and Order if the rules were approved, Kapsch thinks the requirements to provide positioning service and the position accuracy are technical requirements and should be part of the rules.

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Specifically :

- NextNav separated the proposed LMS-5G service out from the existing 47CFR90.205, .353, .357, and created 90.140<x> to cover the proposed new service.
 - Note that the frequency allocations for the new service should have been removed from 90.209 into the new service rules.
- NextNav proposed adding FIXED and MOBILE to the 902-907 MHz band in the non-Federal table in 47CFR2.106.
- NextNav proposed in 90.1403 that the licensee can provide any service that its frequency band segments are allocated.
 - In contrast 90.353 imposes restrictions on the LMS operations.
- Other than definitions in 90.1402, there are no requirements on the provision of or accuracy of positioning and/or timing in the proposed service.

2.4.2 ERP Measurement Method Not Stated In Proposed 90.1408

The proposed rules for LMS-5G do not define whether the LMS-5G ERP density limits apply to peak or rms (average) power.

NextNav has stated in many cases that the intent is to have power limits similar to those for sub-one gigahertz bands :

- *“The M-LMS service and technical rules should align with the Commission’s flexible-use rules (e.g., Part 27) for mobile and/or fixed broadband operations”⁶*
- *“Align the power limits with those that typically apply to Part 27 operations (1000 W/ MHz ERP (1640 W/ MHz EIRP) in densely populated counties and 2000 W/ MHz (3280 W/ MHz EIRP) in counties with 100 or fewer people per square mile) ”⁷*
- *“The effective radiated power (ERP) limits that NextNav proposed in its Petition are based on power spectral density (PSD) to remain consistent with the power limits that apply in other sub-one gigahertz bands”⁸*

The closest comparable Part 27 rules for the power limits and frequencies proposed for 90.1408 appear to be:

- 90.1408(a) is similar to 27.50(b)(4)
- 90.1408(b) is similar to 27.50(b)(5)
- 90.1408(c) is similar to 27.50(b)(10)

The Part 27 rules 27.50(b)(11) and 27.50(b)(12) define that power be measured as rms (average) power.

Previously 90.205(l) defined the 902-928 MHz ERP to be peak ERP. However, NextNav removed LMS-5G from that requirement by the proposal to limit 90.205(l) to only the sub-band 907-918 MHz. However, no measurement statement was added in the proposed 90.1408.

2.4.3 Power Limits Within BS Radius Not Stated In Proposed 90.1408

As stated above NextNav has based their rules on Part 27. But Part 27 includes other restrictions, in particular 27.55(c) as referenced by 27.50(b)(6) that limit the radiated power density at ground level within 1 km of base stations with >1000W ERP to 3 mW/m², but no corresponding text appears in the proposed rules.

⁶ Page 29, [RD1], NextNav petition

⁷ Page A-1, [RD2], NextNav proposed rules

⁸ Page 9, [RD11], NextNav technical study Feb. 2025

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2.5 Issues identified in NextNav Coexistence Submissions

The following items were identified during conduction of this study and in reviewing NextNav responses to other comment submissions with respect to coexistence with NM-LMS. Note that these are additive to or in some cases clarifications of issues already raised, and do not repeat all the issues previously raised.

2.5.1 No Link Budgets And Unclear Service Cell Radius

There is conflict in the cell radius data provided by NextNav. The data from the FCC National Broadband Map appears to give much lower cell radius that stated by NextNav. Also since the LMS-5G system is proposed for both broadband data and also positioning and timing services, information should be provided for both to ensure that the FCC required communication performance for broadband services is supported as well as the positioning and timing services performance stated by NextNav under the same deployment scenarios.

Kapsch recommends that NextNav should provide reference link budgets for the LMS-5G data communications, like the link budgets in the FCC broadband map, repeated here in section 6.1.2, for the outdoor stationary and for tin-building services, as well as for the TPNT service, as well as expected cell radius. The provision of these reference link budgets and cell radius would eliminate much of the uncertainty that has resulted in comment submissions.

NextNav presented simulations for certain geographic regions and only indicated the BS signal levels in the coverage map were “Excellent, Good, Fair or Poor”⁹ and it was not obvious on all the assumptions on the BS-UE links, and on the BS-AVI links, what margins were included and their magnitude. There was no data provided on the orientations between BS and AVI systems, nor levels of RF field strength at the AVI sites.

For the CCDF for UE emissions at readers and transponders, again it was not obvious on all the assumptions and margins used in the UE-BS link, nor the UE-ETC links.

2.5.2 No Reciprocal Coexistence Analysis

NextNav has approached coexistence from only the perspective of LMS-5G interference to established AVI sites. However if there is interference risk from AVI systems into LMS-5G systems, then once LMS-5G is deployed, if the rules are approved, then it would not be acceptable if that impaired the ability to add new AVI sites.

2.5.3 Free-Space Antenna Sidelobe Patterns For BS And Reader Antennas

NextNav stated in their tolling coexistence study that they used the “14 dBi toll reader antenna (above) with orientation toward the incoming traffic with 75° down-tilt”¹⁰ and presented a (free-space) antenna pattern purported to be that of a Kapsch antenna. However this is not the pattern of a Kapsch antenna and the model used to generate this should be identified.

Further, due to local reflections, especially ground and vehicle reflections, the achieved isolation off axis will be reduced from the free-space antenna pattern.

Only a single reader antenna model was used, but different AVI vendors use their own recommended antennas and site settings, so use of a specific pattern is not fully representative.

The NextNav Tolling Coexistence study did not identify the BS antenna model, but the Jan 15 response did reference a BS sector antenna model, with the parameters cited in the NextNav study. However NextNav stated for this antenna “ By contrast, 5G signal levels are reduced by approximately 26 dB at 50 meters separation and approximately 15 dB at 100 meters separation with realistic antenna discrimination”¹¹. However as discussed in section 6.2.4 these numbers are overstated and further for paths with distances close to the base station as indicated in ITU F.1336-5 [AD12] “f) that at large angular distances from the main beam pattern gain may not fully

⁹ e.g. Page 20, [RD7], NextNav Tolling Coexistence Study

¹⁰ Page 30, [RD7], NextNav Tolling Coexistence Study

¹¹ Page 4, [RD16], NextNav Jan 15 2026 Response

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represent the antenna emissions because of local ground reflections.” even further reducing the signal suppression at close distances.

The choice of a BS single antenna for the modelling and use of fixed down-tilt irrespective of terrain does not account for the variations between wireless providers today, especially when they may be adding this band onto existing antennas.

2.5.4 Use Of 902-904 NM-LMS Sub Band

NextNav stated as recently as August 2025 “*contrary to claims about reducing spectrum available for tolling licensees, tolling operators do not use the 902-904 MHz portion of the band today, and NextNav has no knowledge of their planning to do so.*”¹²

Kapsch is aware of at least one agency that Kapsch supports with licensing that does use this sub band to avoid interference to other higher priority federal users in the band: the North Carolina Turnpike Authority has a number of sites under call-sign WQJG520 that use this frequency sub-band for 6C and other protocols, and have used it since 2017. Further there are more sites being deployed by that agency that will use this sub-band.

Loss of this frequency may result in degradations of 6C performance and the other protocols used at those sites as well as the ability to mitigate interference to higher priority users of the band or incumbent users.

2.5.5 Use Of Invalid Path Model For UE To Reader

In the tolling coexistence report NextNav used the 3GPP Urban Micro path loss model with shadow fading to compute the UE interference levels at the reader.¹³ This model is not valid for this interference path. The 3GPP formula for this is for a fixed BS height of 10 m for a base station (in this case reader) and minimum range validity of 10 m, in contrast to the reader at <6 m height, and the interference susceptibility distances <10 m for most protocols for that link. Further shadow fading models in the 3GPP model are for the larger scale effect of buildings and street canyons, which do not apply for the shorter distances between UE in vehicle and reader.

2.5.6 Incorrect Use Of Vehicle Penetration Loss

NextNav continues to use of 5 dB penetration loss for BS interference to transponders¹⁴. The windshield transponder free-space measurements include the effect of the windshield glass, and the windshield transponder is effectively exterior to the vehicle and thus has a penetration loss is 0 dB in the +/- 90 degrees in front of the vehicle. There are also exterior mount transponders which also do not have vehicle penetration loss.

Recognizing that highway toll sites are often bidirectional, 50% of the transponder population passing these sites has 100% probability of 0 dB penetration loss.

The 3GPP models and ITU mean vehicle penetration loss are for devices inside the passenger cabin in the vehicle and for the 360 degree azimuth around the vehicle. NextNav made no statements on the vehicle penetration loss assumed for the BS-UE links in their UE-toll equipment interference analyses. Since 3GPP path loss models are being used, then surely the 3GPP car penetration models [AD10 7.4.3.2] should be used in determining the UE emission power levels. The 3GPP specifically define the additive car penetration loss to be $N(\mu, \sigma_p^2)$, a normal distribution in dB, with $\sigma_p = 5$ and $\mu = 9$ for non-metallized windshield vehicles, $\mu = 20$ for metallized windshield vehicles.

¹² Page 2, cover letter [RD7], NextNav Tolling Coexistence Study

¹³ Page 32, [RD7], NextNav Tolling Coexistence Study

¹⁴ Page 30, [RD7], NextNav Tolling Coexistence Study, and
Page 10, [RD16], NextNav Response Jan 15, 2026

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Since thermal film (metalized) windshields and front side windows are becoming more prevalent in vehicles, the CCDF for UE emissions should be computed taking this into account, and the vehicle penetration loss assumed for the CCDF of UE emissions should be reported.

For UE-reader links, the penetration loss will be lower than the 3GPP models predict, as the link only passes through the front windshield.

2.5.7 Use Of 8 dB For Center Of Capture Zone Margin.

NextNav chose to use 8 dB to indicate the increase in link margin over wake-up conditions when the transponder is at the peak location of the zone, but this is an over-optimistic value when considering the toll system variables and in practice there is a large variation. This is discussed in sections 4.2.1 and 6.2.1.

A fixed increase in link margin can be used to assess how the susceptibility varies with wanted signal power, but not to predict actual levels.

Unfortunately there is not a statistical model of signal margin in capture zones that can be used for analysis. This variation is one of the reasons field testing of susceptibility under real-world conditions is considered necessary.

2.5.8 Incorrect Transponder Antenna Patterns

NextNav used invalid transponder antenna patterns in their Jan 15 response to Neology assessment of out of band emissions impact on 5G systems. NextNav states the data was provided by a third party they commissioned to measure the transponder patterns, but the data was clearly incorrect.

NextNav claim (emphasis added by Kapsch) “*Windshield-mounted toll transponder antenna patterns are typical of bi-directional antennas, where the side lobe and **vertical lobe roll off sharply from 45 degrees to 90 degrees** with respect to the transponder front or back axis.*” and based on that they concluded “*The transponder antenna discrimination to the UE is greatest, up to 30 dB, where the UE is mounted below the transponder, and both the UE and transponder are mounted on the windshield.*”.

There is no vertical lobe roll-off in standard windshield transponders, and it is unclear how NextNav obtained this data, but it is patently untrue that the characteristics presented by NextNav are “typical” of windshield-mounted toll transponder antenna patterns, and the discrimination cited by NextNav for UE’s below the transponders is not valid. The typical free-space antenna patterns for all windshield horizontally polarized toll transponders are classic dipole with omni pattern in vertical (elevation) and figure-8 in horizontal (azimuth). Note this was stated to NextNav during the interactions with E-ZPass on analysis and testing for coexistence prior to NextNav leaving those discussions.

More detail is provided in Section 4.4.

2.5.9 Assuming Adjacent Antennas Will Improve Net Success Rate

NextNav stated the “*net success of an individual vehicle identification is aided by ... additional reads from adjacent lane antennas*”.¹⁵ While a transponder can reply to adjacent antennas in an interference free environment, the wanted signal levels at the transponder will be lower than that from the primary covering antenna. Given the rapid change from 5% PER to 95% PER, if the interference signal is sufficient to impact the primary antenna communication, it is highly probable that no communication will be possible with adjacent antennas.

Further, as identified in section 6.2 shadow fading correlation distance is large and thus the fading will be common across all reader antennas. Thus it is inappropriate to use this as an argument for net success.

The NextNav study only looked at the signal levels for essentially a single channel system. In this study it is shown that even if 2 adjacent channel signals were 10 dB below the primary reader antenna signal at the transponder, their presence made transponders more susceptible affecting both the wake-up sensitivity of the transponder and the interference susceptibility. They also affect the reflected modulated power from the transponders, reducing the signal level at the readers.

¹⁵ Page 5, [RD7], NextNav Tolling Coexistence Study

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2.5.10 Incorrect Application of BS Loading and UE Activity Factors

NextNav used the BS loading and UE activity factors it assumed to affect the RSSI of BS signals and CCDF of UE signals¹⁶.

Comments have already been raised to dispute the values used for BS loading and UE activity by NextNav and are not addressed herein, however additionally Kapsch believe how these are applied is not valid.

NextNav used these factors to adjust the RSSI of signals. Coexistence analysis should first identify where interference can cause issues and then subsequently look at the probability of such interference conditions existing. By applying the BS loading and UE activity factors to the RSSI, NextNav essentially masked the regions where interference could cause issues. These factors should only be applied to the probability of such interference conditions existing.

Further when applying the BS loading and UE activity factors, averages should not be used. Instead the temporal distributions of vehicle traffic at toll sites and the temporal distribution of data traffic in the wireless broadband system should be compared and statistics of vehicle traffic impacted determined. See section 6.2.6 for more detail.

¹⁶ Pages 29 & 32, [RD7], NextNav Tolling Coexistence Study

3. REFERENCES AND DEFINITIONS

3.1 References

Documents are identified in this section in the format:

[Reference Number] Document Number, Revision Document Title, source

... where the reference number is used as xxx in the format [xxx] to refer to the document within the remainder of this document.

3.1.1 Standards and Specifications

[AD1] 47CFR90	Code of Federal Regulations, Title 47, Part 90 - Private Land Mobile Radio Services, Federal Communications Commission
[AD2] 47CFR15	Code of Federal Regulations, Title 47, Part 15 - Radio Frequency Devices, Federal Communications Commission
[AD3] TS 360100-034, Revision C	Active TDM Over-Air Specification for Electronics Toll Communications, Kapsch TrafficCom USA, Inc.
[AD4] ISO/IEC 18000-63:2021	Information technology – Radio frequency identification for item management, Part 63: Parameters for air interface communications at 860 to 960 MHz Type C”, available to purchase at (https://www.iso.org/standard/78309.html)
[AD5] 6C AVI Standard	AVI Standard Requirements And Guidance Document, 6C Coalition
[AD6] Protocol Specification SeGo	Protocol Specification SeGo, Rev D, April 17, 2018, TransCore
[AD7] ASTMv6 Draft	Standard for Dedicated, Short Range, Two-Way Vehicle to Roadside Communications Equipment, ASTM, draft published in 1996.
[AD8] EPC Tag Test Methods	Tag Performance Parameters and Test Methods, v 1.1.3, GS1/EPC Global
[AD9] 5G Specifications	The set of specifications for 5G communications produced by the 3GPP, available at Specifications & Technologies: 3GPP
[AD10] 3GPP TR 38.901 V19.1.0	3GPP Technical Report “Group Radio Access Network; Study on channel model for frequencies from 0.5 to 100 GHz”, (Release 19), 3GPP
[AD11] 3GPP TS 38.101-4 V15.26.0	3GPP Technical Specification “5G;NR: User Equipment (UE) radio transmission and reception; Part 4 : Performance requirements”, (Release 15), 3GPP
[AD12] ITU F.1336-5	Reference radiation patterns of omnidirectional, sectoral and other antennas for the fixed and mobile services for use in sharing studies in the frequency range from 400 MHz to about 70 GHz, ITU.
[AD13] ITU-R m.2334-0	Passive and active antenna systems for base stations of IMT systems, ITU

3.1.2 Other Reference Documents

[RD1] ECFS INBOX-1.401, 16 April 2024	Petition For Rulemaking Of NextNav Inc. In the Matter of Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz), <i>assigned to WTB docket 24-240</i> , NextNav
[RD2] Letter on rules, 7 June, 2024	Re: Rules supplement to NextNav Inc. petition for rulemaking, ECFS INBOX-1.401., <i>assigned to WTB docket 24-240</i> , NextNav

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[RD3] DA 24-776, Aug 6, 2024	Wireless Telecommunications Bureau And Office Of Engineering And Technology Seek Comment On NextNav Petition For Rulemaking, WT Docket No. 24-240, RM-11989, Wireless Telecommunications Bureau
[RD4] IBTTA lab test plan, 31 Jan 2025	5G / Tolling Equipment Interference Lab/Bench Test, IBTTA working group on NextNav, IBTTA
[RD5] UM 360467-110	JANUS® Multi-Protocol Reader 2.4 Operations And Maintenance Manual, Kapsch TrafficCom
[RD6] 7169012329R-00	Test Report as per RSS-137 Issue2:2009 & FCC Part 90 Subpart m on the MRFM-S Plus Model 802870 (FCC ID: JQU 802870), TÜV SÜD Canada Inc.
[RD7] NextNav Licensed Tolling Coexistence Study August 2025	correspondence to FCC Secretary under docket 24-240, dated August 1 2025, with attachment "Licensed Tolling Coexistence Study, August 2025", NextNav
[RD8] E-ZPass/IBTTA tech submission	correspondence to FCC Secretary under docket 24-240, dated December 5 2025, with attachment "NextNav's 5G/Tolling Study: Deeply Flawed and Inadequate to Support NextNav Conclusions", E-ZPass and IBTTA
[RD9] 5G path loss models	https://5g-tools.com/5g-nr-link-budget-calculator/
[RD10] Neology Test Report Dec	correspondence to FCC Secretary under docket 24-240, filed December 15 2025 by Neology with attachment "Technical Report: Coexistence Assessment Between 5G NR and Non-Multilateration LMS Highway Tolling Systems Under NextNav's Proposed Lower 900 MHz Band Plan", Neology
[RD11] NextNav Part 15 Coexistence Study	correspondence to FCC Secretary under docket 24-240, dated February 27 2025, with attachment "5G NR and Unlicensed Part 15 Technologies in the Lower 900 MHz Band, A Coexistence Analysis", NextNav
[RD12] NextNav Part 15 Coexistence 2 nd Study	correspondence to FCC Secretary under docket 24-240, dated July 9 2025, with attachment "Supplement to NextNav's 5G NR and Unlicensed Part 15 Technologies in the Lower 900 MHz Band, A Coexistence Analysis", NextNav
[RD13] Kapsch AVI product datasheets	available at https://www.kapsch.net/en/regions/nam/components
[RD14] Brattle Second Supplemental Report	NextNav correspondence to FCC Secretary under docket 24-240, dated July 17 2025, with attachment "Brattle Second Supplemental Report, Reply To The Harold Furchgott-Roth Filing, An Economic Analysis Of NextNav's Proposal For The Reallocation Of Spectrum And The Modification Of Rules In The Lower 900 MHz Band supplement to NextNav's 5G NR and Unlicensed Part 15 Technologies in the Lower 900 MHz Band", Brattle
[RD15] 7169006613R-000	Test Report as per RSS-137 Issue2:2009 & FCC Part 90 Subpart m on the TRP-8100 Model 802477A- TAB, TÜV SÜD Canada Inc.
[RD16] NextNav 15 Jan 2026	NextNav correspondence to FCC Secretary under docket 24-240, filed January 15, 2026 with attachment "Technical Response to Neology and IBTTA / E-ZPass December 2025 Technical Submissions", NextNav
[RD17] Kapsch Jan 2026	Kapsch TrafficCom correspondence to FCC Secretary under docket 24-240, filed February 19, 2026 titled "Comments Of Kapsch TrafficCom In Regard To Certification Of NM-LMS Equipment To The NextNav Proposed Frequency Plan", Kapsch TrafficCom

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[RD18] NextNav response to SIA, Jan 2026 NextNav correspondence to FCC Secretary under docket 24-240, filed January 30, 2026 containing "Technical Response to Security Industry Association December 2025 Technical Submission", NextNav

3.2 Definitions, Acronyms, Abbreviations

The following may have been used in this document:

3GPP	Third Generation Partnership Project, formed for the 3 rd generation of mobile communications to create standards, and still active and producing the latest generation's standards
5G	Fifth Generation of mobile communications
6C	Radio frequency identification protocol specified by [AD4] and used for tolling as specified by [AD5]
ASTM	American Society for Testing and Materials
AVI	Automatic Vehicle Identification
BS	Base Station, <i>in the proposed LMS-5G service</i>
CCDF	Complementary Cumulative Distribution Function
CDF	Cumulative distribution function
CVO	Commercial Vehicle Operations
d2d	the ground distance used in the 3GPP models for the communication links.
DL	Downlink
ETC	Electronic Toll Collection
FME	Front Mount Exterior Transponder – a specific Kapsch transponder model
ITU	International Telecommunication Union
TPNT	Terrestrial Positioning, Navigation, and Timing Service, <i>service name proposed by NextNav. Note herein the networks that could be deployed under such rule changes are referred to as LMS-5G</i>
E-ZPass	Trade name for the Inter-Agency Group, E-ZPass Group - Home
FCC	Federal Communications Commission
FSPL	Free Space Link Loss
IBTTA	International Bridge, Tunnel and Turnpike Association, Home IBTTA International Bridge, Tunnel and Turnpike Association
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
KPI	Key Performance Indicators – often part of contract requirements.
LMS	Location and Monitoring Service, part of 47CFR Part90
LMS-5G	The network that could be deployed under the proposed rule changes to the LMS spectrum.
MAPL	Maximum acceptable value of PL. The PL plus the margins for statistical variables over the cells like fading, penetration losses and gains like multi-diversity, results in the link loss.
MRPL	Minimum Required value of PL. The PL below which the link loss results in interference greater than the susceptibility level.
M-LMS	Multilateration Location and Monitoring Service (also identified by the FCC as the LS Radio Service), <i>currently permitted under 47CFR90</i>

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NM-LMS	Non-Multilateration Location and Monitoring Service (also identified by the FCC as the LN Radio Service), <i>currently permitted under 47CFR90</i>
NM-LMS-Prop	NextNav proposed revised sub-band allocation for the Non-Multilateration Location and Monitoring Service
OET	Office of Engineering and Technology
PER	Packet Error Rate
PL	A 3GPP propagation loss representing the mean path loss for propagation at a particular ground distance in the cell for the particular link model before other factors like fading, penetration losses, and processing gains are added to arrive at the link loss in the link budget.
PLS	The probability distribution of PL plus statistical variables
RFID	Radio Frequency Identification
RX	Receive
SeGo	RFID protocol specified by [AD6] and used for tolling
TDM	RFID protocol specified by [AD3] and used for tolling
TDMA	RFID protocol specified by [AD7] and used for tolling and CVO.
TX	Transmit
UE	User Equipment, <i>in the proposed LMS-5G service</i>
UL	Uplink
USLS	Upper Sidelobe Suppression
WTB	Wireless Communications Bureau

4. SYSTEMS AND TEST METHODS OVERVIEW

4.1 Summary of NextNav Proposed Change to the LMS Spectrum

Note the following is not intended as a complete summary of the changes proposed by NextNav in [RD1, RD2], but only those points relevant to this susceptibility study:

- Changing the M-LMS spectrum from only a location and monitoring service (LMS) to permit a fifth generation cellular technology (5G)¹⁷ broadband cellular service that, while providing location services, which only will utilize 2-5% of the proposed band capacity [RD1], but the majority of the service capacity will be general 5G service. *Because of this the proposed service is named herein as LMS-5G, to reflect the broader use of the spectrum proposed by NextNav.*
- Changes to the frequency plan that subdivides the spectrum between the proposed LMS-5G sub-band allocations (902-907 MHz and 918-928 MHz) and the proposed revised NM-LMS-Prop sub-band allocation (907-918 MHz) as shown in Figure 4-1.
 - Note the current NM-LMS service sub-band allocations (902-904 MHz and 909.75-921.75 MHz) are the frequency spectrum used for electronic toll collection (ETC), automated commercial vehicle operations (CVO) including pre-clearance, vehicle access and traffic management; railway car monitoring; monitoring and controlling equipment in warehouses; as well as access control at parking lots, airports, and residential communities.
 - Note also the 902-928 MHz band is also allocated for uses other than AVI, in particular unlicensed Part 15 [AD2] services.
 - Furthermore, the Federal Government has various other higher priority uses of the band including the very sensitive wind profiler radar systems manufactured by Radiometrics and Scintec.
 - Note the NextNav figure only identifies the carrier frequencies and does not reflect the guard bands required by emission limits per 47CFR 90.210(k).
- Increase in the power permitted in the new LMS-5G sub-bands to be similar to that permitted for cellular services under 47CFR27 rules compared to the current M-LMS rules.
 - Proposed 1000 W/ MHz maximum average ERP¹⁸ for urban base stations, 2000W/ MHz maximum average ERP for rural base stations, 3 W maximum average ERP for user equipment.
 - Existing M-LMS rules only permit 30 W peak ERP per transmitter in the spectrum adjacent to the NM-LMS sub-bands. Note existing M-LMS services typically only use the downlink portion of the spectrum.

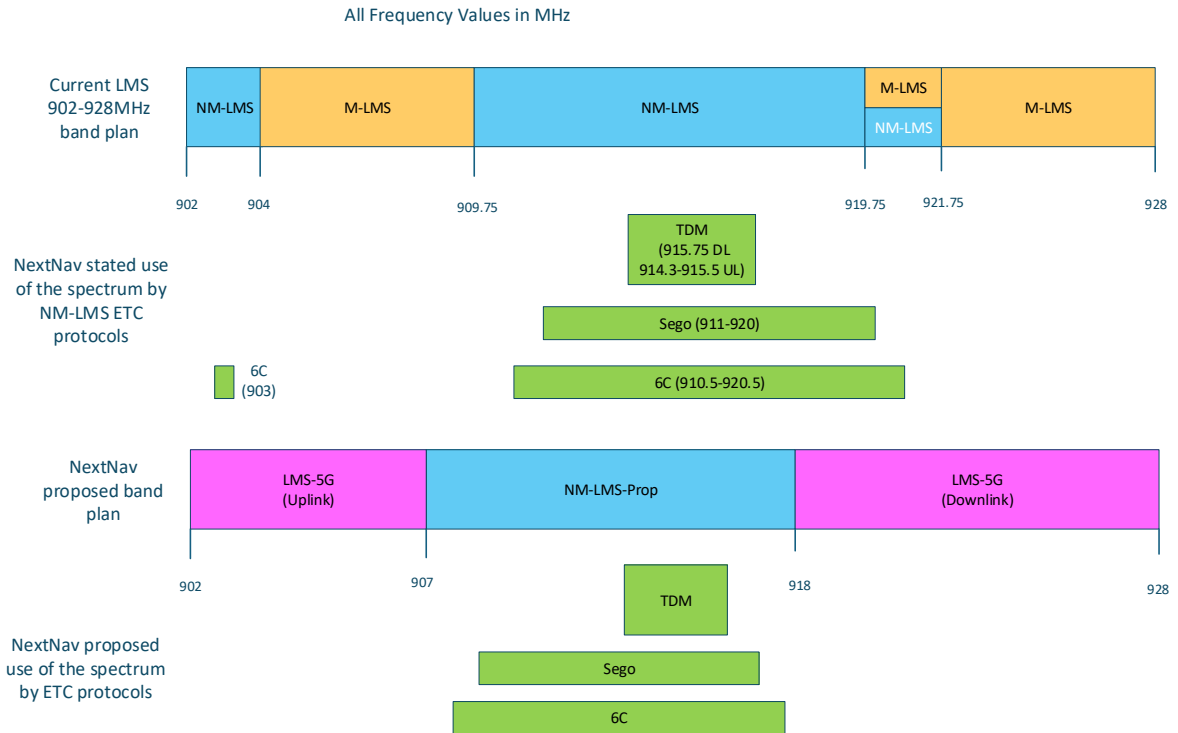
Note also that Kapsch has identified a certification issue in [RD17] related to the proposed rules that may require the ETC frequency plan to be amended to move current TDM and TDMA protocol downlink frequencies lower by ≥ 3 MHz, but this has not been addressed in this test report.

¹⁷ 5G refers to the fifth generation of mobile wireless (cellular) technology, and the technical standards [AD9] are developed by the 3rd Generation Partnership Project (3GPP) in cooperation with the ITU's IMT-2020 program.

¹⁸ See section 2.4.2

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Figure 4-1: NextNav Proposed Revised LMS Frequency Band Plan



Note the figure has been amended from the figure provided by NextNav to reflect the naming of the new sub-bands to avoid confusion, and clarification of the current center frequency ranges.

Note also the frequency ranges refer only to the center frequencies of the ETC and CVO protocol transmissions.

4.2 Reference ETC and CVO Systems

Note that ETC and CVO systems employ linear horizontal polarization.

4.2.1 TDM/6C/SeGo ETC systems

Multilane ETC sites for TDM, 6C and/or SeGo use multiple overhead antennas to cover the lanes to capture transponders in vehicles and correctly associate the transponders to the vehicles in which they are carried and to other system sensors.

Figure 4-2 and Figure 4-3 show the ETC antenna arrangements recommended by Kapsch, reproduced from the Kapsch user manual [RD5]. The coverage area for each antenna is set by adjusting the transmit power of the reader radio connected to the antenna. The circles represent idealized capture zones controlled by downlink transmission and the edge-of-coverage for a zone is set by the transponder wake-up level. The capture zone needs to be sized to nominally have only one vehicle present at a time in a zone.

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Figure 4-2: Kapsch Recommended Antenna Arrangement for Multi-lane ETC using In-Line Antennas.

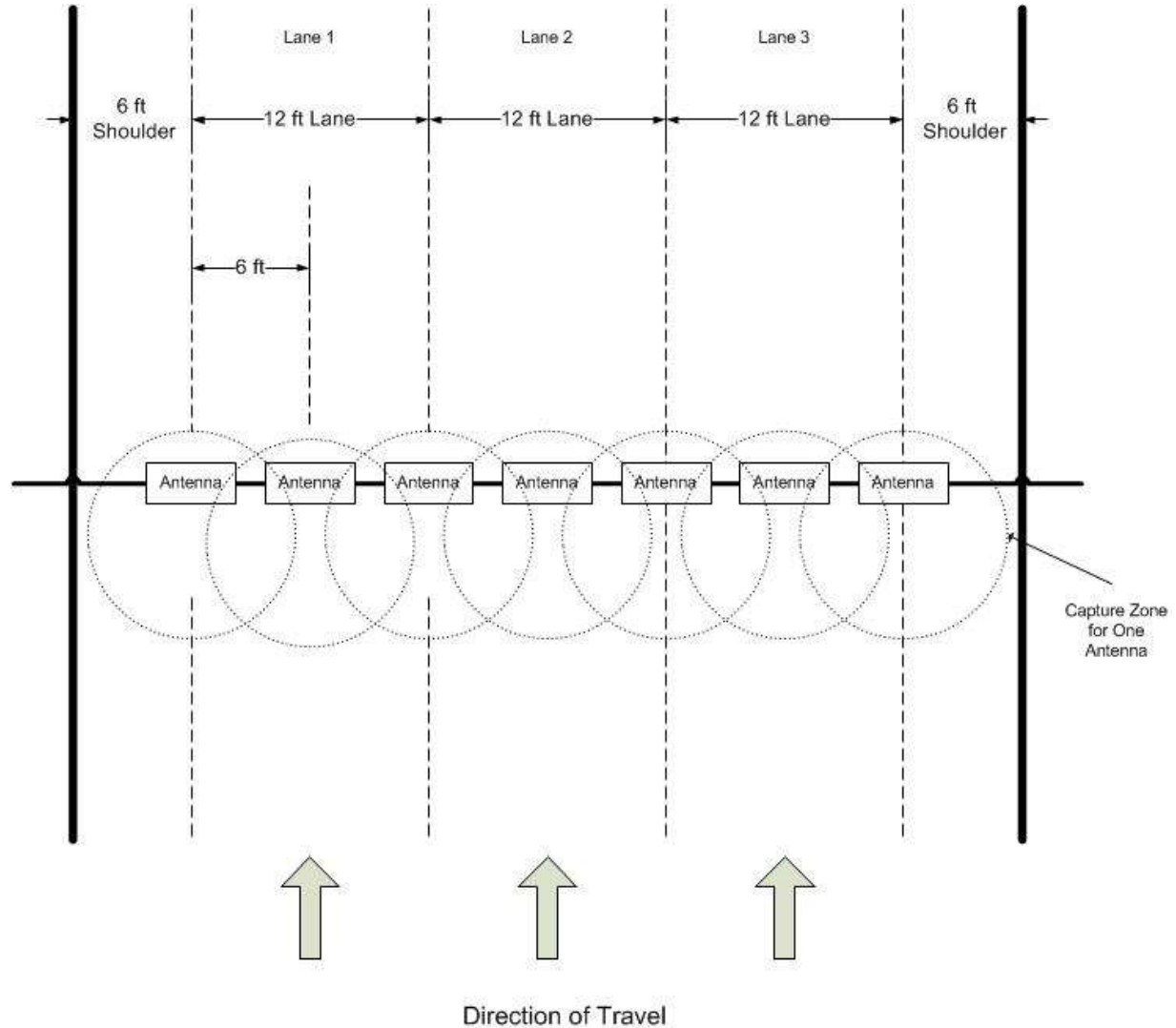


Figure 4-3: Kapsch Recommended Antenna Arrangement for Multi-lane ETC using Staggered Antennas.

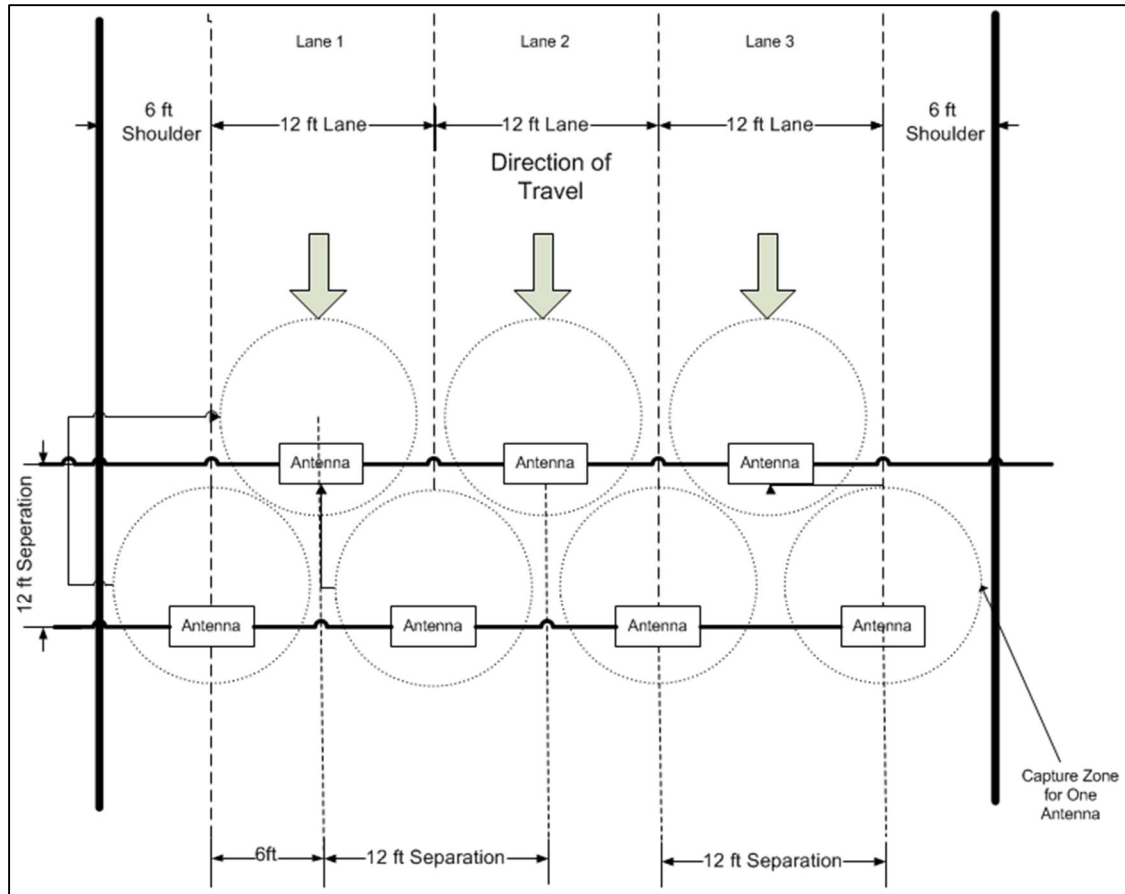


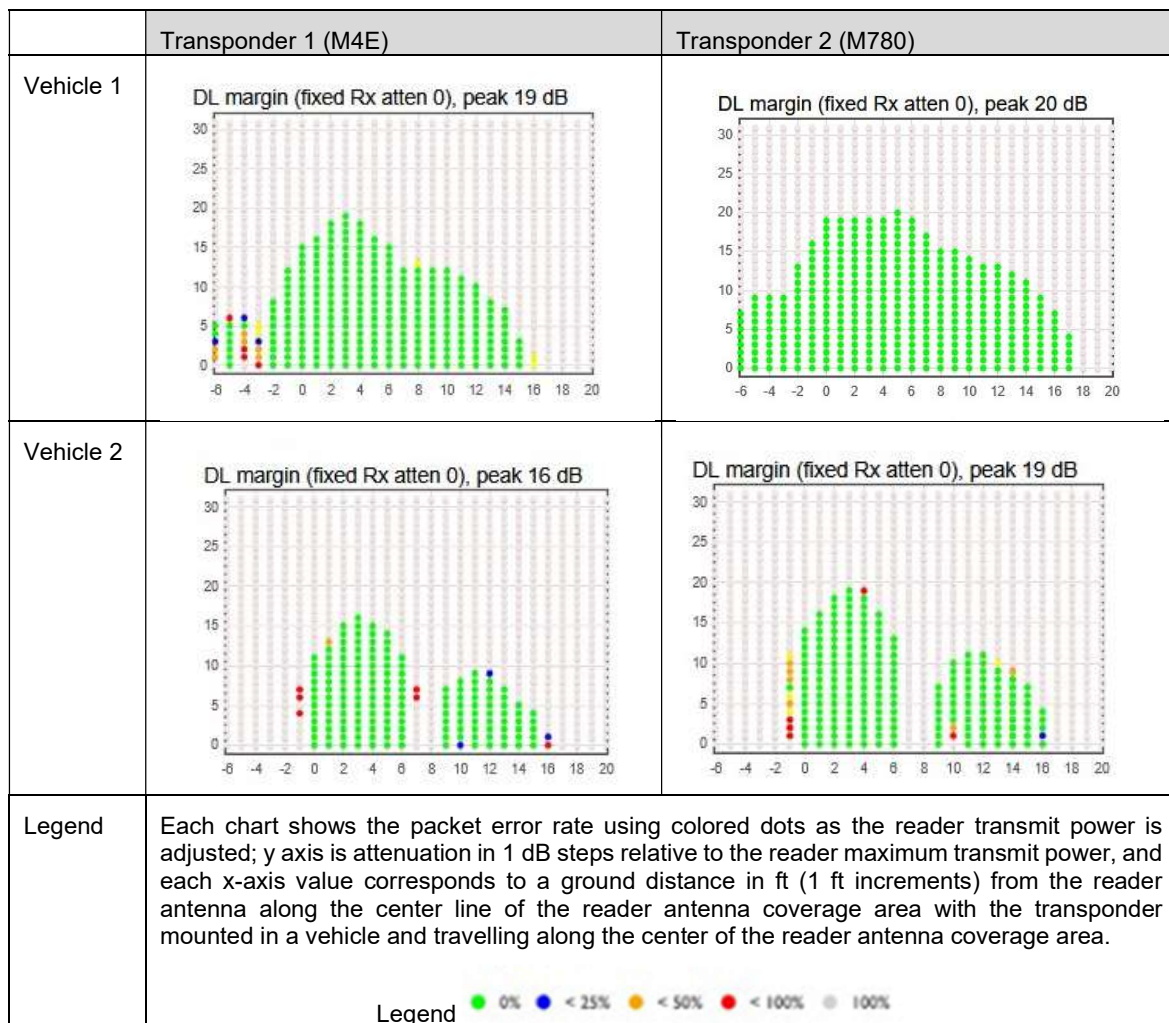
Figure 4-4 shows an example of the downlink power margins measured for a single antenna on a field test site with 2 models of 6C transponder on 2 different vehicles along the center line of an antenna coverage. This figure also highlights some of the vehicle/multipath/transponder variability that is not covered in laboratory testing. This data was for a single vehicle at a time moved through a single toll capture zone. These were not best/worst case vehicles but 2 random vehicles available at the time of test. It also does not reflect the multipath from multiple vehicles being present in the toll site as would be the case in practice.

As stated the ETC systems require not just to read (and write) the transponders but also correctly associate them with the vehicles. Thus lane tuning needs to control the capture zone size for association yet balance this against the transponder capture probability.

Consider if we define Vehicle 1 as a typical response of a "good" vehicle and this type of vehicle is likely used to tune the system – i.e. for this system the TX attenuation might be set at 11 dB. Thus for this vehicle and transponder the possible peak/wake ratio is >7 dB along the center of the capture zone. But in contrast a vehicle like vehicle 2 with the same transponder model would only have a possible 5 dB peak/wake-up and a much shorter (6 ft) capture zone, which reduces the number of handshakes possible. As well there are differences between two transponder models on the same vehicles.

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Figure 4-4: Example of Downlink Margins in Antenna Coverage Area



The reader time multiplexes over the protocols; exercising one protocol at a time, while vehicle transits are not synchronous to the reader timing. At highway speeds therefore, the times when a vehicle with a transponder of a specific protocol aligns with the reader exercising the protocol may not correlate to the peak of the coverage zone, resulting in a reduced “peak” value encountered for that transit and protocol.

The peak values for the capture zone in tuning correspond to the conditions when a “good” transponder passes along the center of the capture zone (reader antenna azimuth of 0 degrees). However this is not true for all cases – consider a headlamp transponder which will not usually be at the center line of the coverage areas of the antennas.

Another factor is that the reader signal from adjacent antennas will be present in the capture zone of a particular antenna and that the strength of the adjacent channel signal relative to the primary channel signal will depend on the alignment of the transponder across the lane and the position along the lane. There is also RF coupling between the reader antennas, resulting in adjacent channel signals being present at the reader. These can affect the transponder sensitivity and interference sensitivity, and testing is reported herein to show the effects.

For the transponder tests reported herein, each adjacent channel signal was set 10 dB below the wanted signal at the transponders. For the reader tests the adjacent channel level at the reader input was set at -18 dBm. Again

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these levels were only established to determine the sensitivity of the equipment to the impact of adjacent channel signals being present. These are not intended to define the specific values that would be encountered in a specific site.

Because of all these variables, it is not reasonable to assign a specific value to peak, average or statistical link margin in a zone for determining separation distance to an interference source. Instead, for the purposes of evaluation, the susceptibility of the transponders and readers was measured at the wake-up conditions, i.e. maximum reader-transponder loss for transponder activation, and also for 7 dB better link margin. Note this 7 dB test value is used to determine the sensitivity of the equipment to the variations in signal level above wake-up, and is not intended to set specific values for a specific site/vehicle.

4.2.2 TDMA CVO Pre-Clearance Systems

The TDMA protocol is used for pre-clearance of vehicles, including weigh-station bypass. Kapsch currently does not supply the readers nor set-up the AVI pre-clearance systems using the TDMA protocol, but has knowledge of the characteristics of some. Kapsch does however supply TDMA transponders used in current North American CVO systems.

Note that a separate CVO test and coexistence report is being considered in partnership with a CVO system operator, and the following is provided for information only.

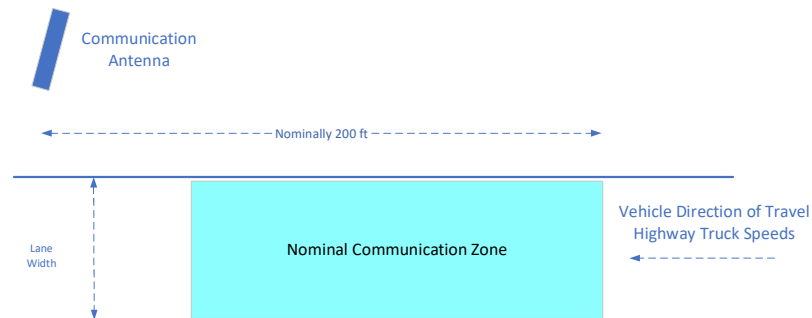
An example current weigh-station bypass site key characteristics are shown in Figure 4-5. The long zone is required because the system needs to obtain data from the transponder, interrogate pre-clearance database(s) and provide notification back to the transponder to alert the driver and to road indicators (e.g. go/no-go lights) while the vehicle travels through the communication zone at highway speeds, and still permit the driver to pull off if the indication is no-go. Multiple transponders will be in the communication zone at any one time.

Because of the larger zone the peak/edge of coverage is larger than the ETC systems, but loss of the transponder responses in the early part of the communication zone will result in the failure to provide the feedback to the vehicle in a timely manner to allow the bypass to occur, so the wake-up conditions are critical to system operation.

In the tests herein the susceptibility of the transponders was assessed for wake-up and also 10 dB higher signal levels.

Note also the larger TDMA capture zones means that the reader antennas are not pointed down towards the road as they are in ETC systems and thus readers would see higher levels of interference from LMS-5G base stations than they would in ETC systems

Figure 4-5: TDMA Pre-Clearance (Weigh Station Bypass) Site Key Characteristics



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4.2.3 TDMA ETC Systems

Kapsch does not currently supply or setup AVI ETC systems using the TDMA protocol, but has supplied them in the past. It does however supply the transponders used in current North American ETC systems.

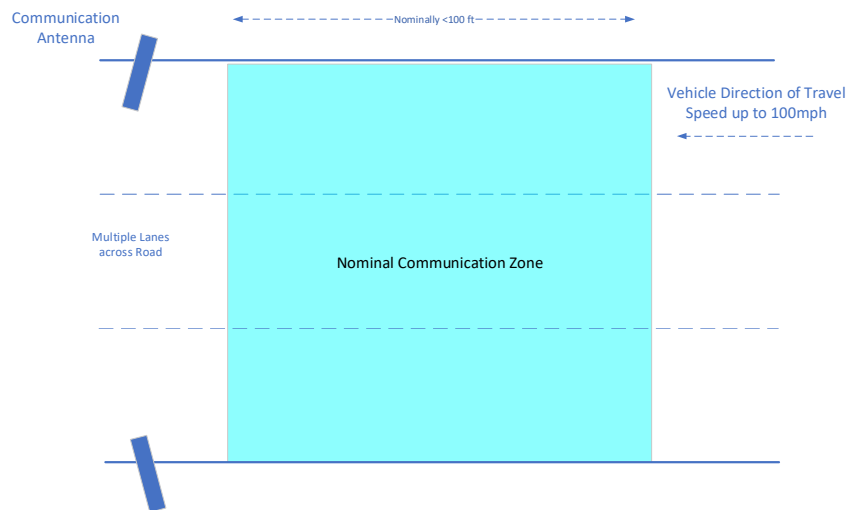
An example TDMA ETC system uses 2 antennas, with alternating transmission, covering multiple lanes and a longer capture zone than the TDM/6C/SeGo ETC systems as shown in Figure 4-6. The longer zone is required because the system employs multiple responses from the transponders to build up vehicle tracks through the zone to associate the transponders to the vehicles and other system sensors. As well the system writes to the transponder to provide audible and visual indication of toll transaction status. As in the pre-clearance applications there will be multiple vehicles in the communication zone at the same time.

Loss of transponder responses will affect the ability to properly associate the transponders to vehicles.

Note also the larger TDMA capture zones means that the reader antennas are not pointed down towards the road at the reader antenna locations and thus readers would be more susceptible to interference from LMS-5G base stations than for TDM/6C/SeGo ETC systems.

In the tests herein the susceptibility of the TDMA transponders was assessed for wake-up and also for 10 dB lower path/pattern loss. Note this 10 dB link margin used herein is only intended to determine the sensitivity of the equipment to the variations in signal level above wake-up. These are not intended to set specific values for specific site assessment.

Figure 4-6: TDMA ETC Site Key Characteristics



4.3 LMS-5G System Characteristics

The NextNav proposal [RD1] is to utilize the proposed LMS-5G sub-bands for a fifth generation cellular technology (5G)¹⁹ broadband cellular service also providing timing and location services that would be a back-up for GPS.

In support of the GPS back-up claim they indicate certain position accuracies that the system will provide. However it is observed that other than their proposed naming of the service, nothing in the proposed rules requires the provision of this GPS back-up capability, nor any position accuracy or geographic coverage requirements. While

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the geographic coverage could be in the Report and Order should the rules be changed, the requirements to provide positioning service and the position accuracy are technical requirements and should be part of the rules.

Specifically :

- NextNav separated the proposed LMS-5G service out from the existing 47CFR90.205, .353, .357, and created 90.140<x> to cover the proposed new service.
 - Note that the sub-band frequency allocations for the new service should have been removed from 90.209 into the proposed new service rules.
- NextNav proposed adding FIXED and MOBILE to the 902-928 MHz band in the non-Federal table in 47CFR2.106.
- NextNav proposed in 90.1403 that the licensee can provide any service that its frequency band segments are allocated. In contrast 90.353 imposes restrictions on the LMS operations.

Other than definitions in 90.1402, there are no requirements on the provision of or accuracy of positioning and/or timing in the proposed service.

5G communications are defined by the technical standards of the 3GPP [AD9] and are based on the usage of orthogonal frequency division multiplexing (OFDM) transmissions. Because the OFDM transmissions involve multiple synchronous simultaneous transmitted sub-carriers, the emissions exhibit high peak to average time domain envelope and spectral density.

Note that the proposed rules do not constrain the proposed sub-bands to 5G systems, and therefore the coexistence analysis herein is limited to services using 5G or equivalent communications with similar peak/average characteristics.

NextNav assumes a 5G NR deployment that was the basis for its tolling coexistence study²⁰ :

- Base stations with:
 - Conducted maximum average transmit power per transmitter: 40 W or 46 dBm
 - Number of transmitters: 4
 - Antenna: 4-port sector antenna with 15.4 dBi gain, HBW of 60 degrees and VBW of 7.6 degrees
 - Total EIRP: 46 dBm + 6 dB (4 Tx) + 15.4 dBi – 1.4 dB (cable loss) = 66 dBm
 - All sites have 3-sector configurations with 0, 120, and 240 degrees for the sector antenna orientations
 - All antennas have 4 degrees down-tilt
- User equipment with :
 - 23 dBm (average) TX power
 - Omni antenna -3 dBi

NextNav made no statements about LMS-5G polarization, however 5G and the previous generation wireless communications currently use dual polarization for both base station transmit and receive and may be using it for user equipment receive. User equipment transmit can use single and may be using dual polarization. For example for BS Verizon cites 2x2 (2 transmit, 2 receive) in the FCC National Broadband Map for sub-GHz while AT&T cites 4x4. For UEs Verizon cites 1x2 while AT&T cites 2x2.

NextNav themselves admitted that for 3-sector antennas the elevation beamwidth can be up to 10 degrees. Further the electrical down-tilt range for the antenna they cite as example is 2 to 12 degrees. By limiting their analysis to a specific set of sector configuration, elevation beamwidth and fixed antenna elevation down-tilt irrespective of terrain heights, the report can hardly be considered comprehensive.

NextNav does not provide any information on the actual cell site spacings nor on link budgets assumed for each of the wireless broadband service, and on the positioning and timing service to achieve the performance they promise,

²⁰ Page 29, [RD7], NextNav Tolling Coexistence Study

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nor the cell-site to toll station distances and geometries in their Tolling Coexistence Study analysis for Kapsch and others to be able to validate their findings. Their Feb 2025 technical study stated inter-site distance was 1732 m for the 3GPP Urban macro model²¹ used in that study, but when compared with cell radius based on Verizon's link budgets in the FCC National Broadband Map there are significant differences, see Section 6.1.2.

Note although 5G employs power control on the UE, however for the purpose of this study, the interference susceptibility is determined first for the maximum average power from the LMS-5G UE and 100% activity. It is understood that full coexistence analysis will take the power control and transmission activity into account but for initial high-level risk assessment, these factors are not considered in this report (see section also 6.2.6).

Note power can be defined as:

Peak Transmit Power – This is the maximum peak power of the transmit waveform envelope or spectral density, as needed for compliance under the current 47CFR90 rules for 902-928 MHz LMS services.

Maximum Transmit Average Power - this is the average power of the waveform when transmitting when transmitters sources are set their maximum operating power, as used for compliance under 47CFR27.

Receive Average Power – this is the average power of the waveform when active at the point of measurement/analysis.

In conducting this study it was recognized that the proposed rules are unclear on the LMS-5G power limits and omit other technical aspects rules in 47CFR27. This is addressed in subsections 4.3.1 and 4.3.2.

With the proposed LMS-5G sub-band of 10 MHz for base station (BS) transmissions and 5 MHz sub-band for user equipment (UE) transmissions, the 5G channel widths of 10 MHz and 5 MHz are applicable. The 5G specifications permit multiple sub-carrier spacings within the channel widths, but for the purpose of this study, and consistent with the NextNav Tolling Coexistence Study [RD7] 15kHz subcarrier spacing will be used. This is also consistent with the link budgets filed for the FCC Broadband Map for sub-GHz bands. From an interference to AVI perspective the subcarrier spacing has no effect, what matters for analysis is the total power over the channel and the cell radius.

The 5G communications also allow power differential between sub-carrier groups and adaptive sub-carrier power control to combat communication impairments. However for the purpose of this assessment, uniform sub-carrier power was used for testing.

A Rhode and Swartz SMBV100B vector signal generator which provides 5G test waveforms was used to simulate the LMS-5G emissions for the tests. The specific 5G test waveforms used are:

BS transmissions : 5G NR TM1-1 FDD Waveform with 10 MHz bandwidth, 15kHz sub-carrier spacing. This exhibits a peak envelope power to average power ratio (PEP) of 10.56 dB.

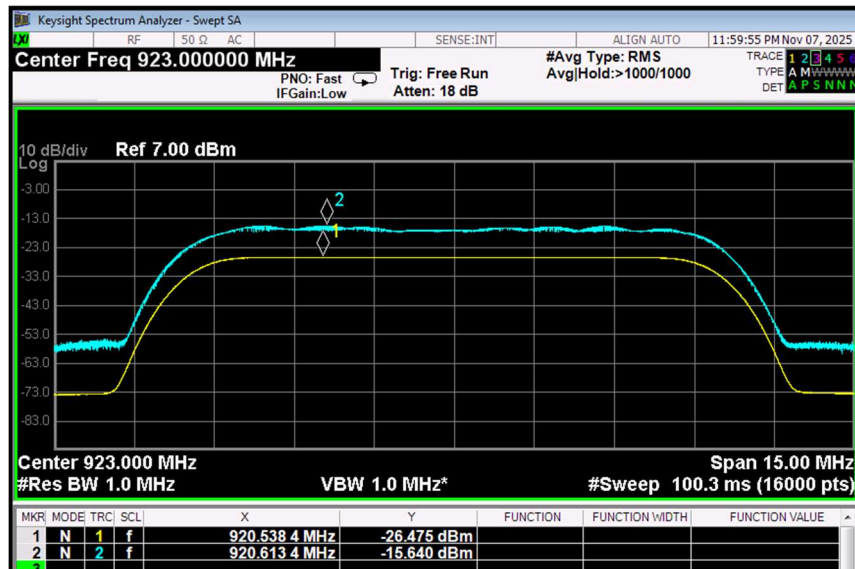
UE transmissions : 5G NR FR1-A1-1 Waveform with 5 MHz bandwidth, 15kHz sub-carrier spacing. This exhibits a peak envelope power to average power ratio (PEP) of 10.77 dB.

In this report average LMS-5G power is used for analysis. For the purpose of interference distance evaluation the LMS-5G BS and UE transmission powers are required. Note that the 5G spectral density exhibits similar peak/average characteristics in both the frequency and time domain as shown in Figure 4-7 through Figure 4-12.

²¹ Page 15 & Table B-1, [RD11], NextNav Feb 2025 technical study

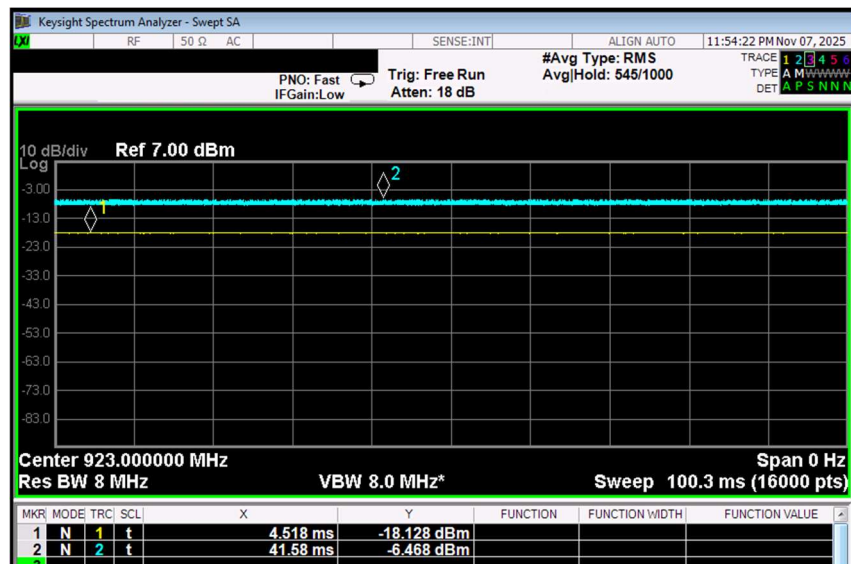
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Figure 4-7: Measured Spectrum for TM1-1 FDD Waveform with 10 MHz bandwidth, 15kHz sub-carrier spacing.



Trace 1 – Yellow - is average power density/ MHz. Trace 2 – Blue - is peak power density/ MHz.

Figure 4-8: Measured Time Domain for TM1-1 FDD Waveform with 10 MHz bandwidth, 15kHz sub-carrier spacing.

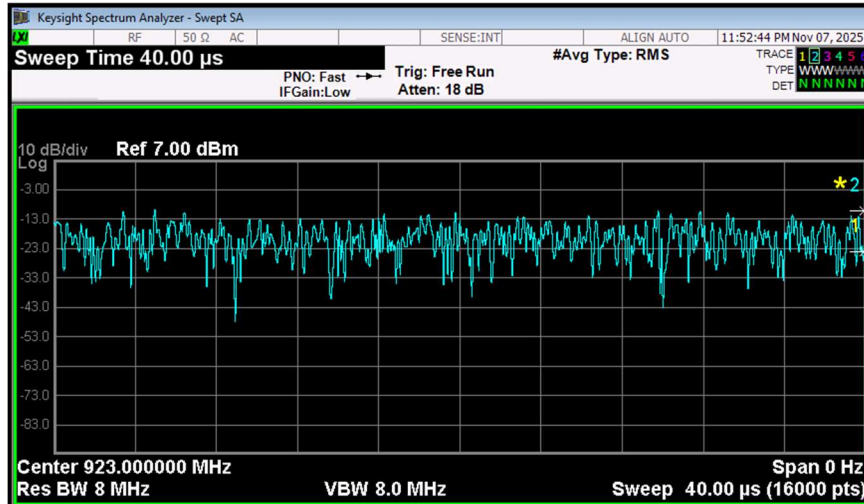


Trace 1 – Yellow - is average power. Trace 2 – Blue - is peak power envelope

Note RBW < Channel Width

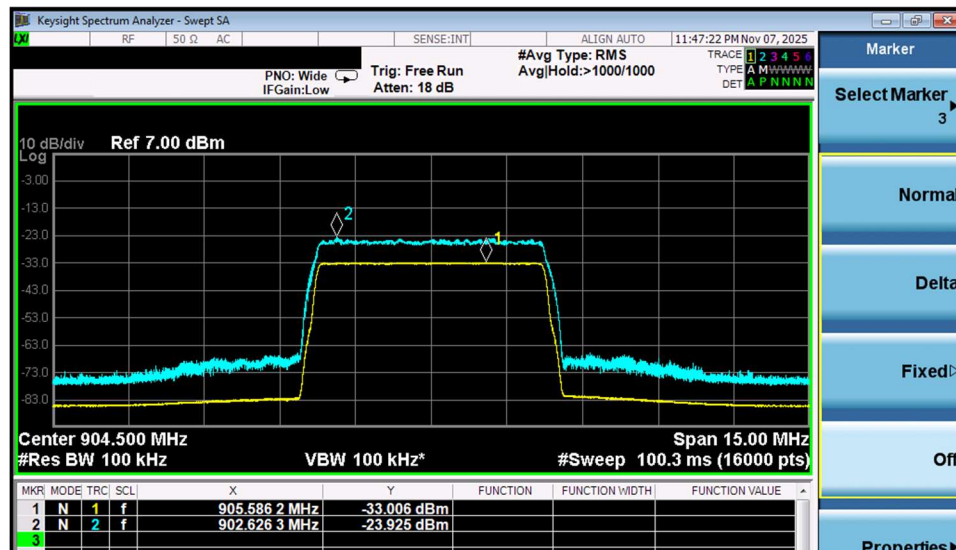
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Figure 4-9: Measured Time Domain Detail for TM1-1 FDD Waveform with 10 MHz bandwidth, 15kHz sub-carrier spacing.



Note RBW < Channel Width

Figure 4-10: Measured Spectrum for FR1-A1-1 Waveform with 5 MHz bandwidth, 15kHz sub-carrier spacing.



Trace 1 – Yellow - is average power density/ MHz. Trace 2 – Blue - is peak power density/ MHz.

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Figure 4-11: Measured Time Domain for FR1-A1-1 Waveform with 5 MHz bandwidth, 15kHz sub-carrier spacing.

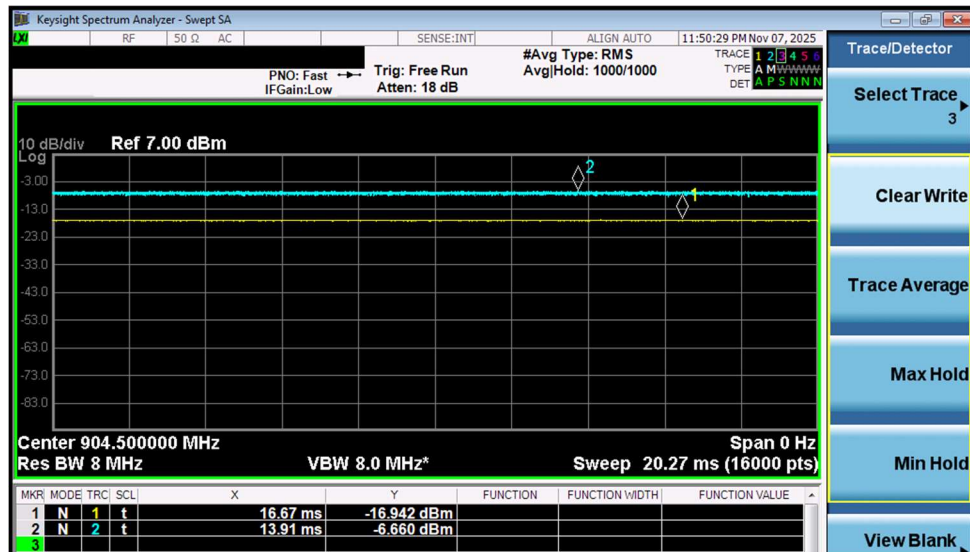
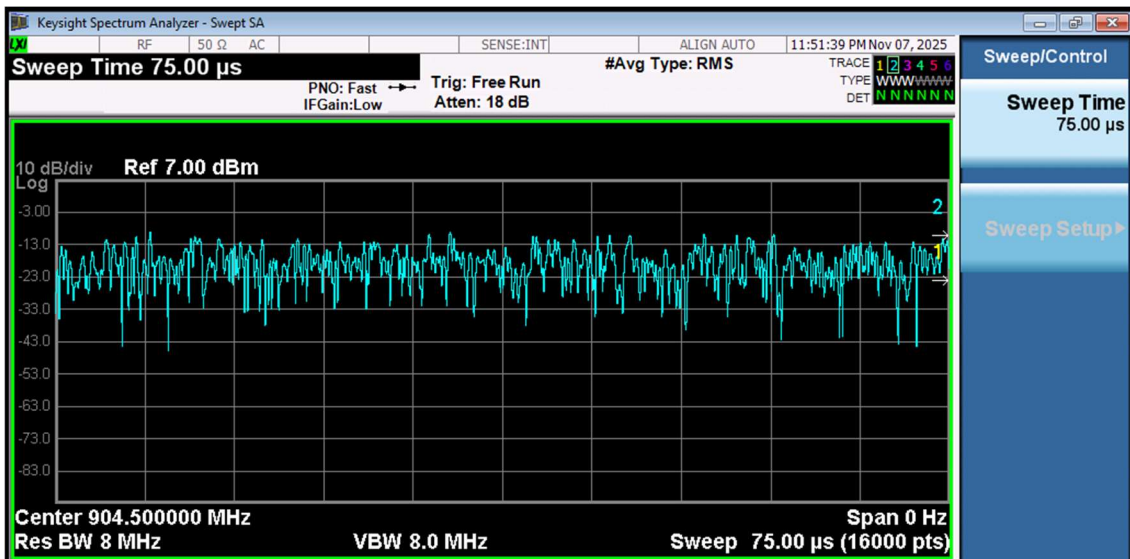


Figure 4-12: Measured Time Domain Detail for FR1-A1-1 Waveform with 10 MHz bandwidth, 15kHz sub-carrier spacing.



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4.3.1 ERP Measurement Method Not Stated In Proposed 90.1408

The proposed rules for LMS-5G do not define whether the LMS-5G ERP density limits apply to peak or rms power. NextNav has stated in many cases that the intent is to have power limits similar to those for sub-one gigahertz bands :

- *“The M-LMS service and technical rules should align with the Commission’s flexible-use rules (e.g., Part 27) for mobile and/or fixed broadband operations”²²*
- *“Align the power limits with those that typically apply to Part 27 operations (1000 W/ MHz ERP (1640 W/ MHz EIRP) in densely populated counties and 2000 W/ MHz (3280 W/ MHz EIRP) in counties with 100 or fewer people per square mile) ”²³*
- *“The effective radiated power (ERP) limits that NextNav proposed in its Petition are based on power spectral density (PSD) to remain consistent with the power limits that apply in other sub-one gigahertz bands”²⁴*

The closest comparable Part 27 rules for the power limits and frequencies proposed for 90.1408 appear to be:

- 90.1408(a) is similar to 27.50(b)(4)
- 90.1408(b) is similar to 27.50(b)(5)
- 90.1408(c) is similar to 27.50(b)(10)

The Part 27 rules 27.50(b)(11) and 27.50(b)(12) define that power be measured as average power.

Previously 90.205(l) defined the 902-928 MHz ERP to be peak ERP. However NextNav removed LMS-5G from that requirement by the proposal to limit 90.205(l) to only the sub-band 907-918 MHz. However no measurement statement was added in the proposed 90.1408.

Without any such proposed rule, and the other NextNav statements it can only be assumed that NextNav intends this to be similar to Part 27.50(b) rules and the proposed limits are therefore defined as average power.

4.3.2 Power Limits Within BS Radius Not Stated In Proposed 90.1408

As stated above NextNav has based their rules on Part 27. But Part 27 includes other restrictions, in particular 27.50(b)(6) and 27.55(c) that limit the radiated power density at ground level within 1 km of base stations with >1000W ERP to 3 mW/m², but no corresponding text appears in the proposed rules.

4.4 Kapsch NM-LMS Equipment

Kapsch supplies NM-LMS certified readers and transponders for ETC and CVO applications, which covers many protocols, however this study only focusses on four protocols :

TDM The Kapsch TDM protocol specification [AD3] is used for ETC and vehicle related applications. This is an “active” protocol whereby the transponders self-generate their RF for transmission response to readers, and uses On-Off Keying (OOK) transmissions.

TDMA The ASTMv6 protocol specification [AD7] is used for ETC, facility access and CVO vehicle credentialling applications. This is an “active” protocol whereby the transponders self-generate their RF for transmission response to readers, and uses OOK transmissions.

6C The 6C protocol is defined by the ISO-18000-63 specification [AD4] as tailored by the 6C Coalition specification [AD5] for ETC and vehicle related applications. Note ISO-18000-63 is used for a very broad set of applications including widespread usage under Part 15 in the LMS spectrum. This is a “passive”

²² Page 29, [RD1], NextNav petition

²³ Page A-1, [RD2], NextNav proposed rules

²⁴ Page 9, [RD14], NextNav technical study Feb 2025

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protocol whereby the transponders backscatter modulate the carrier they receive from the readers to respond to readers.

SeGo The TransCore SeGo specification [AD6] is used for ETC and other applications. This is a “passive” protocol whereby the transponders backscatter modulate the carrier they receive from the readers to respond to readers.

The Kapsch NM-LMS reader products [RD13, see also Appendix A] currently deployed for multi-protocol ETC comprise the Janus MPR2.3 (MPR2.3), Janus MPR2.4 (MPR2.4) and Janus MPR4.1 (MPR4.1), all of which support the TDM, 6C and SeGo protocols. These readers all support operation for multi-lane highways where vehicle speeds up to 100 mph can normally occur.

For the MPR2.3 and MPR 2.4 the radio characteristics are set by the radio modules installed which are plug-in line replaceable units, specifically the MRFMS (FCC ID: JQU 802295A) and the MRFMSP (FCC ID : JQU 802870). Note that the MRFMSP has 3 dB more maximum authorized transmit power than the MRFMS.

The MPR4.1 reader (FCC ID: JQU 802980) radio internal implementation is very close to that of the MRFMSP radio, but the transmit power is limited to the same as the MRFMS. Because of the similarity to the MRFMS, the MPR4.1 reader was not tested, but the results herein are adjusted to cover the MPR4.1 also.

For the tests the latest approved versions of firmware were used for the radio modules.

Kapsch supplies transponders using the TDM, 6C and TDMA protocols [RD13, see also Appendix A]. With the exception of the Front Mount Exterior (FME) transponder, all the transponders exhibit standard free-space dipole gain patterns – approximately uniform over the elevation range and figure-8 over the azimuth range. The FME has shaped elevation pattern and partly directional figure-8 pattern over azimuth.

In [RD16] NextNav has presented data that they claim represent the 3D antenna gain patterns of transponders measured by an independent third party in an anechoic chamber, but the figures and statements appear fundamentally flawed, and are not representative of most windshield toll or CVO transponders. NextNav claim (emphasis added by Kapsch) “*Windshield-mounted toll transponder antenna patterns are typical of bi-directional antennas, where the side lobe and vertical lobe roll off sharply from 45 degrees to 90 degrees with respect to the transponder front or back axis.*” and based on that they concluded “*The transponder antenna discrimination to the UE is greatest, up to 30 dB, where the UE is mounted below the transponder, and both the UE and transponder are mounted on the windshield.*”.

There is no vertical lobe roll-off in standard windshield transponders, and it is unclear how NextNav obtained this data, but it is patently untrue that the characteristics presented by NextNav are “typical” of windshield-mounted toll transponder antenna patterns, and the discrimination cited by NextNav for UE’s below the transponders is not valid.

NextNav presented an antenna pattern²⁵ for a TDM transponder identified by NextNav as being from a Kapsch G5 (FCC ID: JQU 9801660C) transponder from Ohio and they also cited the FCC certification for that product. Note the FCC certification data on record does not contain any antenna pattern information, but inspection of the FCC data on file shows the antenna is a printed track on a standard thin dielectric substrate and therefore one would expect the antenna pattern to be approximately a classic dipole as shown in shown in Figure 4-13, which is the actual antenna pattern for the G4E transponder (FCC ID JQU 8021660B) and its successor the G5 transponder (FCC ID: JQU 801660C). Kapsch is and has been the predominant supplier of TDM transponders to E-ZPass agencies including Ohio agencies and in particular there are approximately 1.2 million Kapsch windshield transponders currently active under said Ohio agencies, and overall over 40 million such transponders active in E-ZPass. Clearly there is no vertical lobe, but instead a near uniform omni pattern in elevation.

Similarly NextNav presented an antenna pattern²⁶ for a 6C transponder identified by NextNav as being from a UNI Tag transponder. Transcore has advised Kapsch that this transponder also has a standard dipole antenna characteristic. Note also that the UNI Tag is a multi-protocol hard-case toll transponder and cannot be considered as a “typical” 6C windshield transponder. The predominant 6C windshield toll transponders are “sticker”

²⁵ Figure 2, page 14 of [RD16], Next Nav response Jan 15, 2026

²⁶ Figure 1, page 13 of [RD16] , Next Nav response Jan 15, 2026

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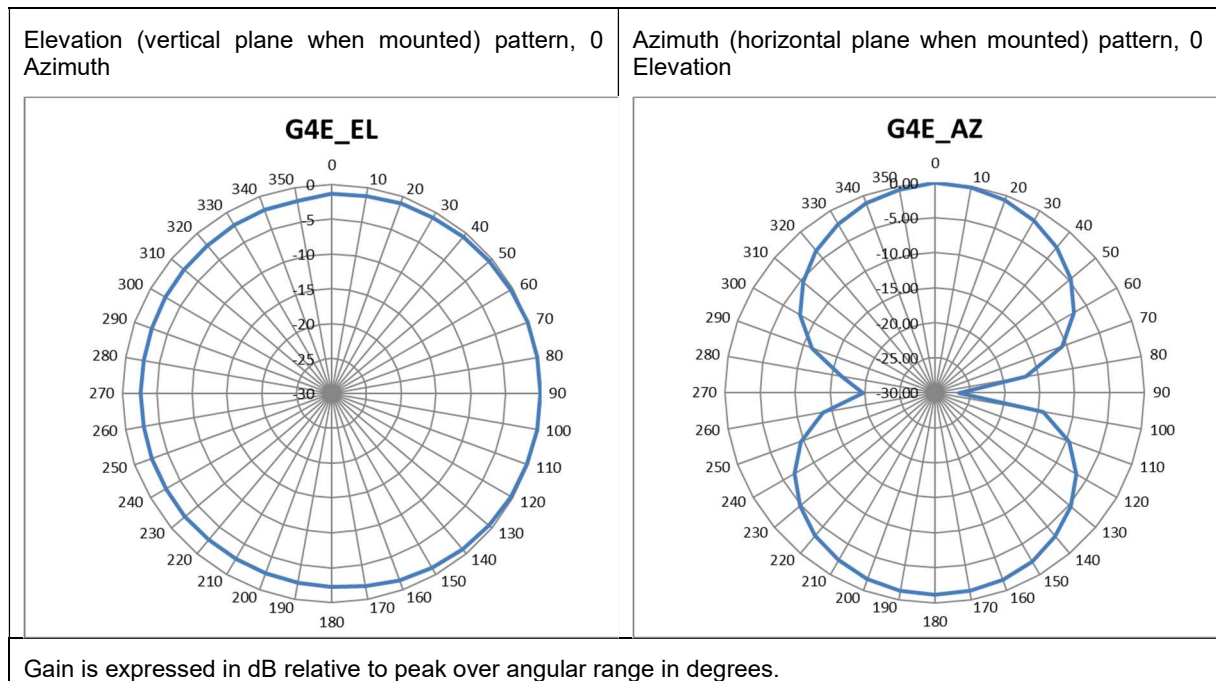
transponders (see appendix A for example) and again exhibit classic dipole antenna pattern as demonstrated in Figure 4-14.

Similarly NextNav presented an antenna pattern²⁷ for a SeGo transponder identified by NextNav as being a SunPass transponder, which is ambiguous since SunPass offer at least 2 transponders²⁸, one being the SunPass Mini, a sticker transponder representing the majority of deployed windshield transponders; the other being a multi-protocol hardcase transponder SunPass Pro, which is the same design as the UNI tag, as reported by E-ZPass/IBTTA²⁹, but in either case they both have standard dipole antenna patterns. Also the SunPass Pro cannot be considered as “typical” for SeGo transponders.

Finally, Kapsch TDMA windshield transponders again are printed antenna patterns on thin dielectric as evidenced by the FCC exhibits for these transponders, and again have approximately classic dipole antenna patterns.

Note that the free-space antenna patterns do not necessarily match the antenna patterns on vehicle. In particular the near-field and reflective effects of vehicle mirror, roof, hood and electronics can distort the windshield antenna pattern in both azimuth and elevation and cause the peak gain to increase.

Figure 4-13: G4E Windshield Transponder Free-Space Antenna Gain Pattern



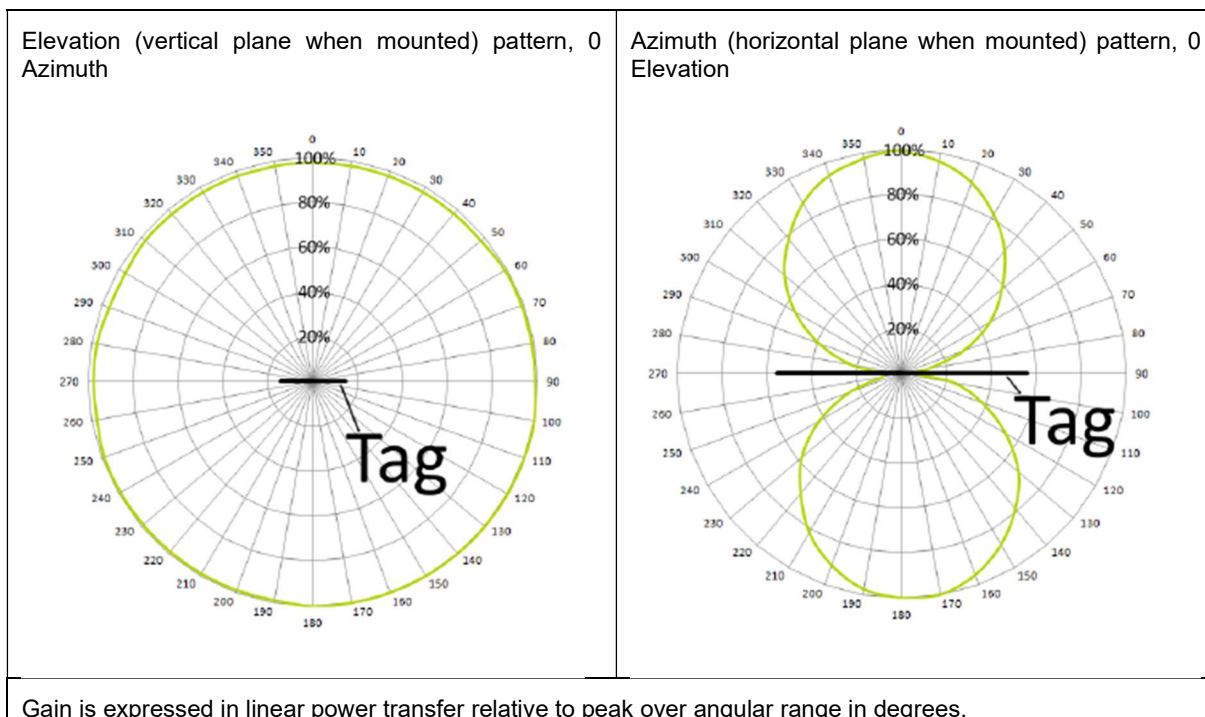
²⁷ Figure 3, page 14 of [RD16] , Next Nav response Jan 15, 2026

²⁸ <https://www.sunpass.com/en/about/aboutsunpass.shtml>

²⁹ Page 8 of [RD8], E-ZPass & IBTTA submission Dec 2026

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Figure 4-14: Typical 6C Windshield Sticker Transponder Free-Space Antenna Pattern



The Kapsch TDM protocol transponders tested herein for susceptibility to LMS-5G interference were:

G4E (FCC ID : JQU 801660B) - windshield hardcase transponder

note this is representative for the G4F (JQU 80197) transponder variant, so that was not tested.

G5 (FCC ID : JQU 801660C) - windshield hardcase transponder

HOT (FCC ID : JQU 802120A) - windshield hardcase transponder with switch to allow the user to declare occupancy status

FME (FCC ID : JQU 801800C) – external to vehicle hardcase transponder

note the FME is used for multiple vehicle locations including on vehicle license plates, front bumpers, front grilles, and on the top of commercial vehicle cabs. The gain and antenna pattern are substantially affected by the mounting location.

The Kapsch 6C protocol transponders tested were :

Kapsch windshield sticker transponder. There have been 3 generations for these which differ in the ASIC used and therefore the antenna matching. The ASICs are:

- Alien Higgs3
- Impinj Monza M4E
- Impinj Monza M780

Kapsch 3-position switchable windshield hardcase transponder which uses the NXP 7XM ASIC and has a switch to allow the user to declare occupancy status.

Kapsch also supplies 6C headlamp sticker transponders, but these are similar to the windshield sticker transponders, and were not tested - the free-space sensitivity results for windshield transponders herein are applicable for these also.

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Kapsch does not supply SeGo protocol transponders but to test the readers and provide an example transponder data a Florida SunPass Mini sticker tag was measured.

Kapsch supplies transponders for the ASTMv6 (TDMA) protocol. The Kapsch TDMA transponders tested were:

CVO with self-test button (CVO-ST) (FCC ID: JQU 801604A) – windshield hardcase transponder for automated vehicle clearing operations

Variants of this transponder exist, but the CVO-ST results are applicable for the variants.

TRP-8100 transponder (FCC ID: JQU 802477A) – windshield hardcase transponder used for ETC and other operations

4.5 Kapsch ETC Frequency Plans

The Kapsch readers, and TDM and TDMA protocol transponders, are all 47CFR90 Subpart m certified NM-LMS equipment and readers are limited by design to only the frequencies in the current NM-LMS sub-bands 902-904 MHz and 909.75-921.75 MHz (47CFR 90.353). Further the approved frequencies in the sub-band for the protocols being assessed are restricted by compliance to the sub-band emission limits 47CFR 90.210(k)(6) and for the 909.75-921.75 MHz sub-band the edges at which emission masks must be met are 909.5 MHz³⁰ and 921.75 MHz. The resulting grant frequencies are listed in Table 4-1. Note that the emission spectra of the products are primarily a result of the protocol specification characteristics.

Table 4-1: Current FCC Authorized Center Frequencies for Kapsch Multiprotocol NM-LMS Readers Downlink Transmissions

	MRFMS JQU 802295A	MRFMSP & MPR4.1 JQU 802870 & JQU 802290
Grant : TDM	915.75 MHz	
Grant : 6C	903 MHz and 910.5 – 920.5 MHz	903 MHz and 910.5 – 920.5 MHz
	2.25 MHz lost to emission guard band	2.25 MHz lost to emission guard band
Grant : SeGo	911.5 - 919.5 MHz	911.0 – 920.0 MHz
	4.25 MHz lost to emission guard band	3.25 MHz lost to emission guard band

Note the 902-204 MHz band is also authorized for Kapsch readers for other tolling protocols that are not addressed in this study.

NextNav stated as recently as August 2025 “*contrary to claims about reducing spectrum available for tolling licensees, tolling operators do not use the 902-904 MHz portion of the band today, and NextNav has no knowledge of their planning to do so.*”³¹

Kapsch is aware of at least one agency that Kapsch supports with licensing that does use this sub band : the North Carolina Turnpike Authority has a number of sites under call-sign WQJG520 that use this frequency sub-band for 6C and other protocols, and have used it since 2017, to avoid interference to higher priority federal users of the band. Further there are more sites being deployed by that agency that will use this sub-band. As stated by

³⁰ Note although the sub-band edge is 909.75 MHz, the emission mask in 47CFR90.210(k)(6) applies at 909.5 MHz.

³¹ Page 2, cover letter [RD7], NextNav Tolling Coexistence Study

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previously by the ETC community, loss of this frequency may result in degradations of 6C performance and the other protocols used at those sites.

For deployment for passive protocols in multi-lane systems, the Kapsch required frequency plan is a 4-channel frequency plan with 2.5 MHz spacing required between channel center frequencies [RD5 Appendix]. Note that the frequencies may be reused if more than 4 antennas are deployed, and simultaneous transmission occurs on all antennas for passive protocols. Current Kapsch multi-protocol readers also only provide channel center frequencies with 0.5 MHz resolution for passive protocols.

NextNav have proposed changing to the NM-LMS-Prop sub-band of 907-918 MHz. This implies the Kapsch readers will be restricted by emission mask for passive protocols to closest to band edge frequencies 908.5 and 916.5 MHz. With the 11 MHz wide proposed sub-band, this means >1.5 MHz guard band at each end of the sub-band may be possible. Note however this guard band means the MRFMS (JQU 802295A) radios would no longer be compliant to 47CFR 90.210(k).

Allowing 1.5 MHz at each end of the sub-band only permits 2 options for 4-channel frequency sets in the NextNav NM-LMS-Prop with 1.5 MHz guard band at each end and the current 0.5 MHz center frequency resolution :

908.5, 911.0, 913.5, and 916.0 MHz, or

909.0, 911.5, 914.0, and 916.5 MHz

If either guard band requires to be increased above 2 MHz, or both require 2 MHz, then there is no solution to a 4 channel frequency plan with 11 MHz sub-band and toll system performance degradations can be expected.

The NextNav proposed LMS-5G base station (BS) emissions are 5G NR 10 MHz channel width centered on 923 MHz and user equipment (UE) emissions are 5G NR 5 MHz channel width centered on 904.5 MHz.

Because the Kapsch readers cannot be set to 908.5 MHz for testing the passive protocols, it was decided to set 911 MHz for the reader frequency for testing LMS-5G UL for both 6C and SeGo, and the 5G NR UE band was shifted to be centered on 907 MHz when testing passive protocols, to maintain the 1.5 MHz sub-band edge separation to the closest frequency channel used for test. Note that since the Kapsch readers already support also the 902-904 MHz band for passive protocols, the frequency shift is not expected to affect the susceptibility test results. Based on this the test conditions implemented were those listed in Table 4-2.

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Table 4-2: Frequency Plans Used for Tests

Test Case	Reader Transmit frequency tested (MHz)	Adjacent Reader channel frequencies (MHz) (1)	LMS-5G interference test center frequency (MHz)	LMS-5G interference waveform
TDM RDR or TAG DL INTF	915.75 (2)	n/a	923	5G NR TM1-1 FDD Waveform with 10 MHz bandwidth, 15kHz sub-carrier spacing
TDMA TAG DL INTF (3)	915.75 (2)	n/a		
6C or SeGo RDR or TAG DL INTF	916.5	n/a		
6C or SeGo RDR or TAG DL INTF ADJ		914, 911.5		
6C or SeGo RDR DL INTF 0.5 m	916.0	n/a		
6C RDR DL INTF 0.5 m ADJ (4)		913.5, 911		
6C or SeGo TAG DL INTF nxtCH	914	n/a		
6C RDR DL INTF nxtCH (4)				
TDM RDR or TAG UL INTF	915.75 (2)	n/a	904.5	5G NR FR1-A1-1 Waveform with 5 MHz bandwidth, 15kHz sub-carrier spacing.
TDMA TAG UL INTF (3)	915.75 (2)	n/a		
6C or SeGo RDR or TAG UL INTF	911	n/a	907	
6C or SeGo RDR or TAG UL INTF ADJ		913.5, 916		
6C or SeGo RDR UL INTF 0.5	911.5	n/a		
6C RDR UL INTF 0.5 ADJ (4)		914, 916.5		
6C or SeGo TAG UL INTF nxtCH	913.5	n/a		
6C RDR UL INTF nxtCH (4)				

Note (1) Tests were performed with both the adjacent channels off and separately on. For transponder tests these adjacent channel frequencies are each set each ~10 dB below the channel frequency under test. For reader testing these adjacent channel frequencies were each set at -18 dBm at the reader input – which is representative of conditions that have been seen by Kapsch in the field.

Note (2) Transponder transmits nominally at 915 MHz. The protocol spec [AD3] permits 914.3 – 915.5 MHz center frequency.

Note (3) Kapsch currently only supplies TDMA transponders so only interference to transponders was tested.

Note (4) Only 6C tested, since SeGo performance already good on reader.

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4.6 Test System used for Susceptibility Measurements

The laboratory measurements for this study were conducted for the purpose of measuring the free-space susceptibility at transponder boresight conditions at different signal levels at the transponder and with differing LMS-5G interference.

In the AVI/CVO applications a bi-directional link is required between the reader and transponder in order to determine that the communication is taking place.

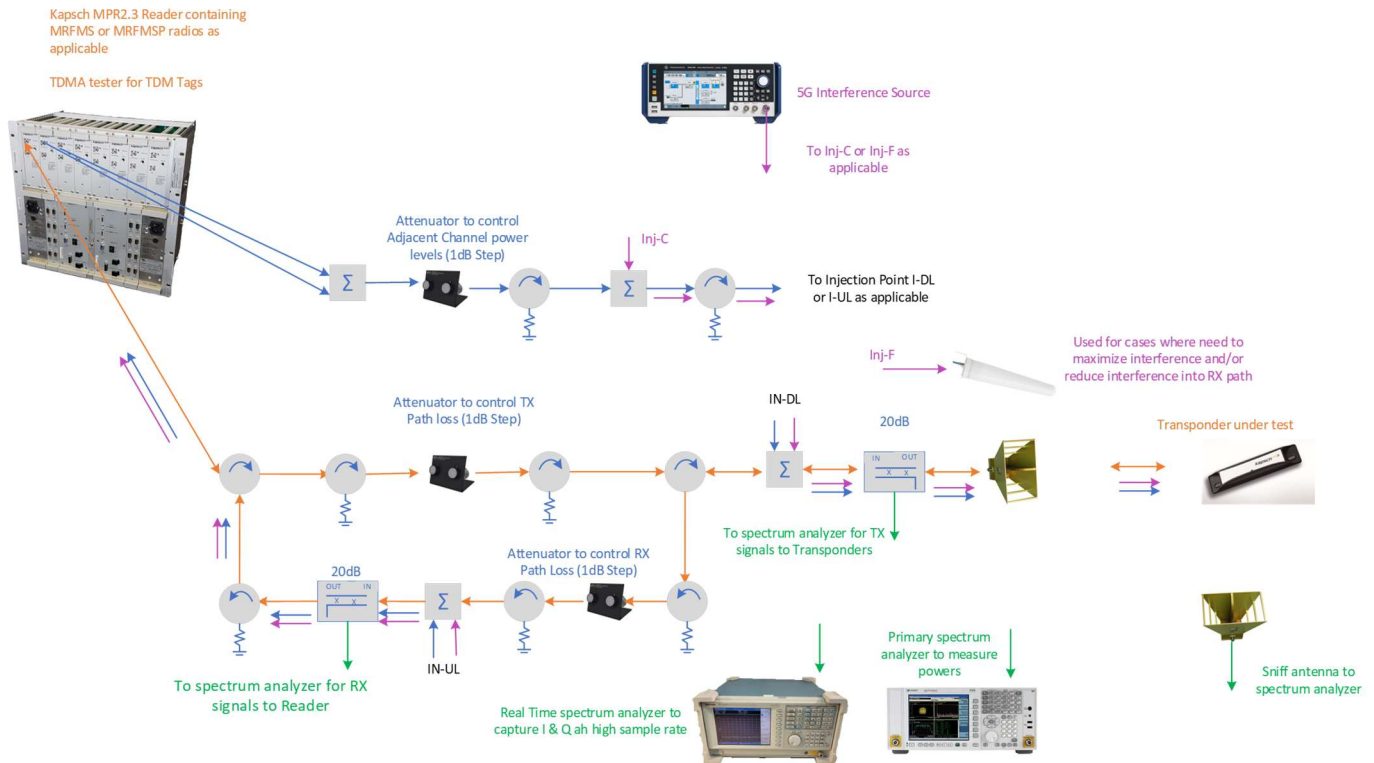
The test setup was arranged to allow injection of interference and adjacent reader channel signals into the receive path of the item being assessed (transponder or reader), while ensuring the level of the added signals was not affecting the equipment on the other end of the reciprocal link.

4.6.1 Free-Space Test Setup

The test setup employed for measuring the RF performance is shown functionally in Figure 4-15. It was arranged so that with only a few cable connection changes it could be switched between testing transponder or reader susceptibility to interference. The key equipment used in the testing is listed in Table 4-3.

For testing all transponders were oriented at physical boresight (0 degrees azimuth and elevation in the direction of the T/R antenna).

Figure 4-15: Test Setup



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Table 4-3: Key Test Equipment

Item	Model	Notes
Interference Source	Rhode & Swartz SMBV100B-3/K31	Vector Signal Generator with High Output Power This was capable of sourcing +19 dBm average power for the 5G NR signals, with output power control to 0.01 dB resolution..
	RS-SMBVB-TP/K144-5G NR	Licenses needed to produce 5G NR waveforms
	RS-SMBVB-TP/K148-5G NR Rel 16	
	RS-SMBVB-TP/K250	
	RS-SMBVB-TP/K61	
Spectrum Analyzers	Keysight CXA Signal Analyzer N9000A	Used to measure signals to transponder and interferer power in channel bandwidth
	Tektronix RSA3408	Used to obtain I & Q data on uplink signals to reader with >=20 MHz measurement bandwidth. This data was then processed to remove the carrier and band-limit to the signal of interest to measure the modulated signal power at the reader input for passive transponders. (See average power level over the receive message in Section 4.6.2)
Test System Couplers	Mini-circuits ZDGC10-362HP+	High directivity 20 dB N-type directional couplers
Test System Attenuators	JFW 50BR-008 Benchtop Attenuator	For setting TX and RX path loss in test set to 1 dB resolution.
T/R antenna	AH Systems SAS-571	Horn antenna to send signals to the transponder and receive them from the transponder.
Sniff Antenna	AH Systems SAS-571	Horn antenna used to pick up over-air signals and observe them on a spectrum analyzer. Useful to see if transponder is responding or generating false responses.
Interference antenna	E connectivity LP800-2500-9-NF Log Periodic Dual-Band Antenna	Used to send interference to transponder independently of T/R antenna to reduce interference and carrier levels seen by reader.
Current Measurement	Fluke 25	Used to measure current drawn by instrumented transponders with microamp capability
Power Supply	BK Precision 9110	DC supply used for current measurements
TDMA Tester	Kapsch Test Reader	Reader to interrogate TDMA transponders with handshake reporting

4.6.2 Test Data Collection

The reader signal level was adjusted using the external TX attenuator in the test set till the transponder just wakes up – i.e. responds to reader transmissions. Note the TX attenuator has 1 dB step size while the difference between no response and responding 100% of the time is a small fraction of a dB. This level, referred to herein as “wake-up”, therefore establishes a reader-transponder path loss simulating the Reader-Transponder downlink conditions at the edge of coverage zone for that transponder in the ETC or CVO system.

The external RX attenuator in the test set, also 1 dB step size, was adjusted to set the path loss for transponder-reader to be equal to the reader-transponder path loss³², thus setting a reference signal power at the reader input to simulate the receive conditions at a reader at the wake-up conditions in the ETC or CVO system. The signal levels at the reader and transponder were recorded. The measurement of signal level at the reader can and has been converted into equivalent EIRP from the transponder.

The interference power was then adjusted to the condition just before the interference starts affecting the packet error rate (PER). For each measurement data point the interference levels were recorded and the PER determined over >1000 transponder interrogations to 1% resolution. Interference levels were normally incremented in 0.5 dB steps so that PER range from 0 to 100 percent was covered. Then the set of results were analyzed to determine the interference levels for 5% and 95% PER.

The external TX and RX attenuations were then reduced by 7 dB (10 dB for TDMA), to determine the effect of transponders moving closer to the peak of the coverage zone (see Section 4.2), and the set of measurements repeated. This also ensures that changes in the backscatter reflectivity of the passive transponders with increasing receive power can be observed.

Note that the sensitivity power levels determined in the test results in Section 5 are expressed as received power that would be received by an isotropic antenna dBm(i)³³. Similarly the transponder modulated power radiated to the reader is expressed as average effective radiated power from an isotropic antenna (EIRP) in dBm. The values reported correspond to:

TDM, TDMA TX from Reader – peak envelope of the OOK trigger pulse or modulated data transmission.

6C, SeGo TX from Reader – carrier power level

Interference – average power level, determined as channel power over the 5G NR channel width

RX at reader – average power level over the modulated receive message computed as:

$$10 * \log_{10} \left(\frac{\sum ((i_n - \bar{i})^2 + (q_n - \bar{q})^2)}{N} \right)$$

where

i_n and q_n are the individual I and Q voltage samples of the modulation at baseband, captured by the RSA 3408A spectrum analyzer, and after processing to rotate to zero frequency, filtering to band limit noise and normalizing to voltage for 0 dBm.

$\bar{i}$ and $\bar{q}$ are the averages over the message.

Note this corresponds to the methodology specified by EPC Global [AD8] for computing modulated received signal power.

Note that TDM and TDMA transponder EIRPs in the protocol specifications [AD3, AD7] are expressed as the peak power for the ON condition of the OOK modulation, which is 6 dB higher than the average power over the message as reported herein.

³² This is the condition for tag-reader path loss used by NextNav in their tolling Coexistence study [RD7].

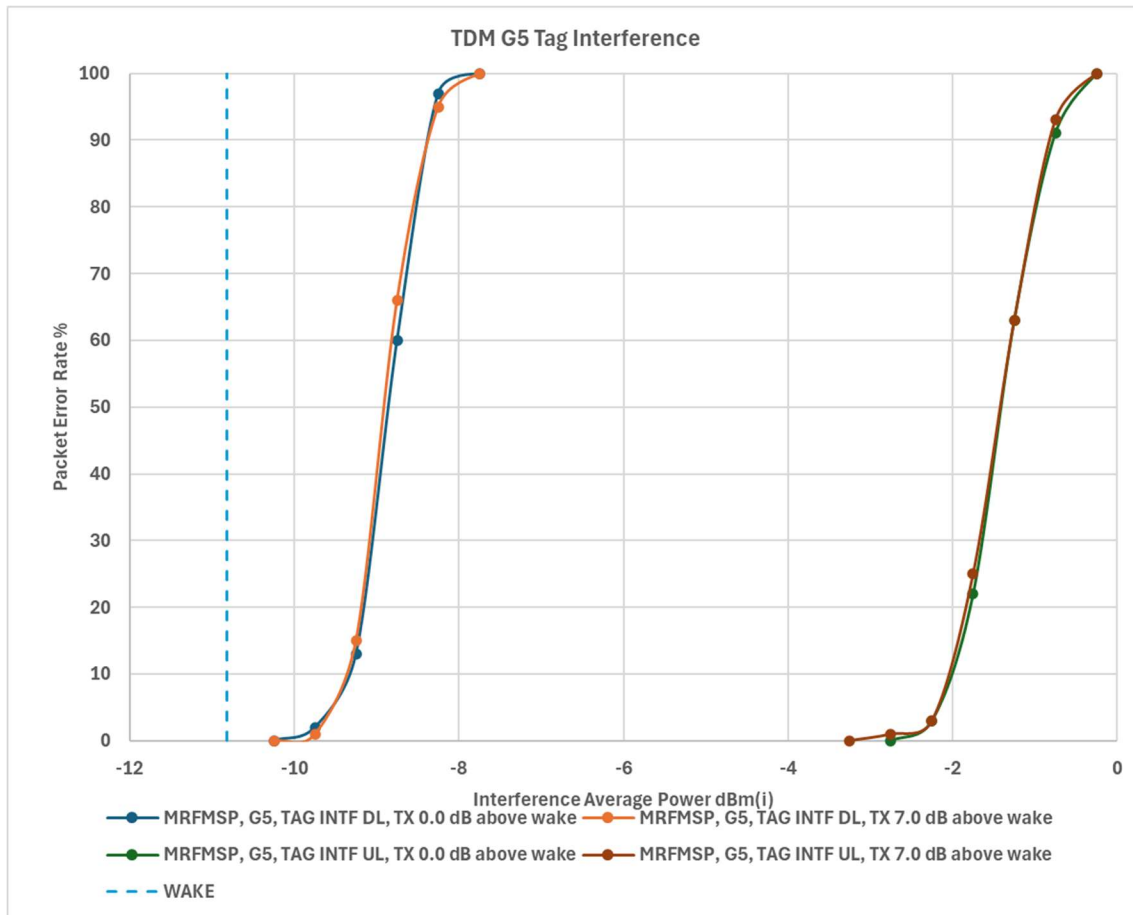
³³ Kapsch uses dBm(i) to distinguish between received power and radiated power, and to reflect it is not the power actually received at the circuit unless the antenna gain is 0 dBi.

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An example plot of the measured data samples for a device is shown in Figure 4-16 for the PER versus absolute interference and wake-up power levels, with an example plot of the same PER versus interference to signal ratio shown in Figure 4-17.

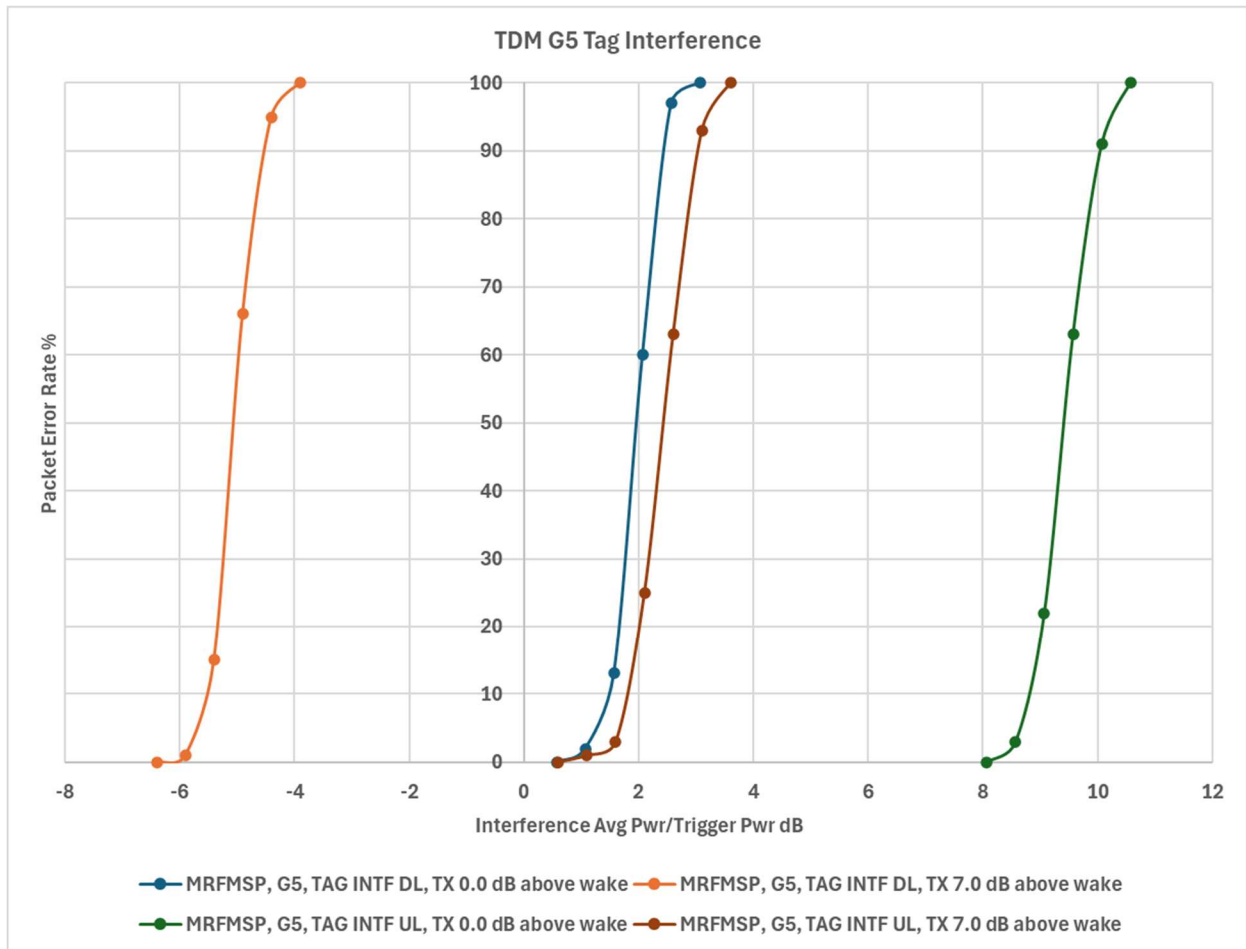
In the test measurement data later, when susceptibility was solely a function of interference power and not dependent on received power, as in Figure 4-16, the actual interference level is reported, whereas when the susceptibility is dependent on the wanted received signal power, the interference/signal ratio is reported.

Figure 4-16: Example Interference and Wake-up Power Measurement Data



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Figure 4-17: Example Interference/Signal Measurement Data



5. TEST MEASUREMENT RESULTS

The sub-sections to this contain the measurement data recorded by Kapsch for the Kapsch NM-LMS products tested using the test system.

5.1 Summary of Test Results

Table 5-1 reports the average interference levels for the transponders measured. The table uses the average data recorded over the measured transponders under adjacent channel conditions for passive transponders (-10 dB below wanted carrier each of 2 carriers). Note these are free-space values.

The Kapsch testing only covered 4 TDM transponder models, 1 SeGo transponder (non-Kapsch) and 2 6C tag models from Kapsch, with 3 different ASICs in one model.

Table 5-1 summarizes the average results per protocol measured for transponder susceptibility in terms of absolute interference power. The table also reports the NextNav results for susceptibility. Note one lack of clarity with the NextNav report is that it does not define if their levels at the transponder are dBm(d) or dBm(i), and the latter has been assumed. The shaded cells indicate where the susceptibility recorded was at a lower LMS-5G power than recorded by NextNav.

Some key points were determined for Kapsch transponders:

- Kapsch TDM transponders employ a fixed wake-up threshold, and as a result the susceptibility is only dependent on interference to wake-up ratio. This also means that the interference levels at wake-up will affect the entire coverage zone and that the interference from base stations will affect all the lanes in the system.
- Kapsch TDM and TDMA transponders are less susceptible to uplink interference than downlink interference, due to the RF filters inside the transponders.
- For Kapsch transponders for all other protocols, the susceptibility is dependent on the interference to signal ratio.
- TDM transponders also exhibit false responses (i.e. they are triggered to respond by the 5G interference) when the interference level is above that causing 5% PER. This is shown in more detail in Section 5.4.
- TDM transponder Write is 2-3 dB more susceptible than TDM transponder Read.
- The transponder currents for TDM start to show increases with the DL interference below the wake-up threshold, and as interference rises the current rises to a level of 23 times the normal current, except for the false response region where the current can reach over 1000 times the normal current.
- The transponder currents for TDMA shows increases with the DL interference below the wake-up threshold, and as interference rises the current rapidly rises to a level approximately 300 times the normal current.
- The presence of adjacent carriers at the passive transponders makes some transponders more sensitive to the reader signals and affects the susceptibility levels. It also affects the transponder backscatter ratio for the primary carrier, and hence the signal at the reader. The interference power at the transponder may also affect the transponder backscatter ratio, but this was not measured during this study.
- The passive transponders are not affected by the frequency offset between the interference and the reader signals. Note this means that the interference from base stations will affect all the lanes in the system, irrespective of the reader frequency plans used.

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Table 5-1: Summary of Measured Transponder Free Space Receive Susceptibility to LMS-5G Signals

Scenario	Protocol	Average Interference power (dBm(i)) for 5% PER at Wake-Up	Average +7 dB RDR-TAG path loss Interference power (dBm(i))	5%-95% PER Average Change (dB)	Susceptibility variation measured (dB) (4)
BS to Windshield or Headlamp Transponder	TDM	Read: -12 Write: -14		3	2.5
		Current (2): -18 for 1.5x -10 for 23x -9 for 1000x -6 for 23x		n/a	n/m
	6C	-24	-16	5	6.2
	SeGo (3)	-17	-12	2	n/a
	TDMA	-36	-30 (1)	3	1.7
		Current (2): -28 for 300x		n/a	n/m
BS to Other Exterior Transponder	TDM	Read: -16 Write: -18		5	n/m
		Current (2): -19 for 1.5x -13 for 23x -12 for 1000x -9 for 23x		n/a	n/m
UE to Windshield Transponder	TDM	Read: -5 Write: -8		3	2.9
		Current (2): -11 for 1.5x -3 for 23x -2 for 1000x +1 for 23x		n/a	n/m
	6C	-25	-16	5	6.1
	SeGo (3)	-16	-11	2	n/m
	TDMA	-17	-8 (1)	3	0
		Current (2): -8 for 300x		n/a	n/m
NextNav reported UE values ³⁴	TDM 6C SeGo	>- 24		Not provided	

Note (1) Adjusted for +7 dB link margin

Note (2) Current entries (xx for yy) are interference power level xx in dBm(i) for the current to increase to yy multiples of normal current outside toll zones.

Note (3) This is not a Kapsch tag but was measured to get coverage of all 3 protocols. Only a single tag type measured.

Note (4) : n/m = not measured or population too small

³⁴ Page 17, [RD7], NextNav Tolling Coexistence Study

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Table 5-2 summarizes the results for reader susceptibility recorded on Kapsch Reader radios. In establishing the data in this table:

- The average transponder signal power used the MRFMSP data from Table 5-8. The MRFMS and MPR4.1 data was adjusted to account for the 3 dB lower tolerable path loss.
- The 6C and SeGo data is the average of the data recorded under the test adjacent channel conditions.
- The interference/signal sensitivity used the I/S data from Table 5-12 for the MRFMS and Table 5-15 for the MRFMSP and MPR4.1.
- The interference power levels for 5% PER were then determined from the above 2 data sets.
- The table contains estimated data for TDMA reader performance using levels measured on the TDMA tester but apply Kapsch reader susceptibilities for TDM. This was established on the following basis:
 - TDM and TDMA transponders use the same modulation characteristics : OOK with Manchester encoding and 500 kbps data rate.

The table also contains the data that NextNav reported, and shaded cells in the Kapsch data are where the reader is more susceptible than NextNav reports on the readers(s) they tested. This serves to reinforce the fact that NextNav should not generalize the results of limited tests to be representative.

Some key points determined for the readers are:

- The TDM susceptibility to LMS-5G BS interference is over 40 dB worse than the data presented by NextNav. It is noted that the MRFMS has similar TDM receive circuitry to the units previously tested against the Progeny system interference in 2015.
- Reader TDM susceptibility for MRFMS was similar for wake-up conditions and with +7 dB reader-tag link margin. For MRFMSP (and MPR4.1) it improved with reader-tag link margin.
- The MRFMSP and MPR4.1 have better susceptibility performance than the MRFMS except when:
 - the passive 6C carrier channel center frequency is 1.5 MHz from the sub-band edge, and
 - for SeGo UE interference.
- The MRFMS is not very sensitive to channel offset from the band edge, while the MRFMSP showed a few dB improvement.
- The readers susceptibility was not materially affected by the presence of adjacent channels at the reader input.

One point to note is the measurements on TDM and TDMA transponders were at ambient and the transponders were at beginning of life. TDM and TDMA transponder output power is a function of battery voltage which will drop over temperature and towards end of life. At that point the signal level at the reader will drop resulting in a corresponding lower susceptibility level for the interference.

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Table 5-2: Reader Average Receive Conducted Power Susceptibility to LMS-5G Signals

Scenario	Protocol	At Wake-up			At +7 dB downlink path margin			5%-95% PER Change (dB)
		MRFMS	MRFMSP	MPR4.1	MRFMS	MRFMSP	MPR4.1	
Transponder Signal Power (dBm) at wake-up at reader	TDM	-55	-58	-55	-48	-51	-48	
	TDMA (4)	-66	-69	-66	-66	-69	-66	
	6C	-65	-68	-65	-55	-58	-55	
	SeGo	-62	-65	-62	-47	-50	-47	
BS I/S (dB)	TDM & TDMA (4)	-12	-5		-18	-5		3
	6C	49	33 / 48 (1)		44	37 / (2) (1)		
	SeGo	51	55		42	48		
UE I/S (dB)	TDM & TDMA (4)	24	58		18	54		
	6C	45	32 / 48 (1)		41	33 / (2) (1)		
	SeGo	47	54		38	46		
BS Interference Power (dBm) to Reader	TDM	-67	-63	-60	-66	-56	-53	3
	TDMA (4)	-78	-74	-71	-84	-74	-71	
	6C	-16	-35 / -20 (1)	-32 / -17 (1)	-11	-21 / -10 (1, 3)	-18 / -7 (1, 3)	
	SeGo	-11	-10	-7	-5	-2	1	
UE Interference Power (dBm) to Reader	TDM	-31	0	3	-30	3	6	
	TDMA (4)	-40	-9	-6	-39	-6	-3	
	6C	-16	-33 / -17 (1)	-30 / -14 (1)	-14	-17 / -2 (1, 3)	-14 / +1 (1, 3)	
	SeGo	-15	-11	-8	-9	-4	-1	
NextNav reported BS values ³⁵	TDM	-23			-23			Not provided
	6C	-40			-24			
	SeGo	>-3			>-3			
NextNav Reported UE values ³⁶	TDM	-26			-26			
	6C	-18			-18			
	SeGo	>-3			>-3			

Note (1) : 1.5 MHz and 2.0 MHz channel center frequency from band edge

Note (2) : 2.0 MHz band edge was not recorded

Note (3) : 2 MHz performance estimated based on results at wake-up

Note (4) : TMDA reader results are extrapolations based on TDM results.

³⁵ Page 16, [RD7], nearest channel to DL, NextNav Tolling Coexistence Study

³⁶ Page 16, [RD7], nearest channel to UL, NextNav Tolling Coexistence Study, *note offset to interference was incorrect.*

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5.2 Transponder Susceptibility

Table 2-1 is repeated here defining the test settings.

Table 5-3: Frequency Plans Used for Tests

Test Case	Reader Transmit frequency tested (MHz)	Adjacent Reader channel frequencies (MHz) (1)	LMS-5G interference test center frequency (MHz)	LMS-5G interference waveform
TDM RDR or TAG DL INTF	915.75 (2)	n/a	923	5G NR TM1-1 FDD Waveform with 10 MHz bandwidth, 15kHz sub-carrier spacing
TDMA TAG DL INTF (3)	915.75 (2)	n/a		
6C or SeGo RDR or TAG DL INTF	916.5	n/a		
6C or SeGo RDR or TAG DL INTF ADJ		914, 911.5		
6C or SeGo RDR DL INTF 0.5 m	916.0	n/a		
6C RDR DL INTF 0.5 m ADJ (4)		913.5, 911		
6C or SeGo TAG DL INTF nxtCH	914	n/a		
6C RDR DL INTF nxtCH (4)				
TDM RDR or TAG UL INTF	915.75 (2)	n/a	904.5	5G NR FR1-A1-1 Waveform with 5 MHz bandwidth, 15kHz sub-carrier spacing.
TDMA TAG UL INTF (3)	915.75 (2)	n/a		
6C or SeGo RDR or TAG UL INTF	911	n/a	907	
6C or SeGo RDR or TAG UL INTF ADJ		913.5, 916		
6C or SeGo RDR UL INTF 0.5	911.5	n/a		
6C RDR UL INTF 0.5 ADJ (4)		914, 916.5		
6C or SeGo TAG UL INTF nxtCH	913.5	n/a		
6C RDR UL INTF nxtCH (4)				

Note (1) Tests were performed with both the adjacent channels off and separately on. For transponder tests these adjacent channel frequencies are each set each ~10 dB below the channel frequency under test, while for reader tests they were each set -18 dBm.

Note (2) Transponder transmits nominally at 915 MHz. The protocol spec [AD3] permits 914.3 – 915.5 MHz center frequency.

Note (3) Kapsch currently only supplies TDMA transponders so only interference to transponders was tested.

Note (4) Only 6C tested, since SeGo performance already good on reader.

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Table 5-4 lists the susceptibility information for the Kapsch TDM transponders. Kapsch TDM transponders employ a fixed receive threshold, and as a result the susceptibility is only dependent on interference to Wake-up ratio. Note for this reason the table uses actual interference level (I) rather than interference/signal level (I/S) which is used for all other protocols.

As a reminder For Kapsch TDM windshield transponders the wake-up level in free space is typically -12 dBm(i).

Kapsch Exterior TDM transponders (FME) are more sensitive by approximately 5 dB (at Az =0, EI=0) to result in similar capture zones in the ETC system. As shown in Table 5-9 the exterior transponder EIRP has a similar difference, which means the uplink signal levels from both will have similar power at the reader for the same location in the zone, as shown in Table 5-8. Note that this 5 dB is for free space. Because the FME can be mounted on metal surfaces changing the antenna pattern and gain the sensitivity and hence susceptibility can be a few dBs more sensitive on the vehicle. This has not been factored into the coexistence assessment later.

Note that the TDMA susceptibility data in Table 5-9 is a prediction of what it would be if the Kapsch readers were used today for TDMA in the same toll sites as the other 3 protocols. Currently this is not the case.

Kapsch TDM transponders contain RF filters, so that they have different interference susceptibility to LMS-5G BS and UE signals.

Table 5-4: TDM Transponders Receive Read Susceptibility to LMS-5G Signals

Transponder	Test Case	Wake up level (dBm(i)) (1)	I at Wake (PER 5%) (dBm(i))	I at Wake+7 dB (PER 5%) (dBm(i))	I ratio (dB) for PER 5%-95% at Wake	I ratio (dB) for PER 5%-95% at Wake+7 dB
TDM : G4E	TAG DL INTF	-11.8	-11.8	-11.9	3.7	3.9
TDM : HOT		-12.3	-13.4	-13.4	2.8	2.9
TDM : G5		-11.8	-10.9	-10.9	1.6	1.8
TDM : FME		-17.2	-16.0	-16.2	4.5	4.8
TDM : G4E	TAG UL INTF	-10.8	-5.2	-5.3	4.0	4.2
TDM : HOT		-11.3	-6.3	-6.4	2.7	2.8
TDM : G5		-10.8	-3.4	-3.4	1.9	1.9
TDM : FME		-17.2	Unable to detect up to limit of test system (~1 dBm(i))			

Note (1) Actual wake-up is 0 to -1 dB below reported value – due to test set attenuator only 1 dB step size

Table 5-5 lists the susceptibility of the 6C transponders tested. The sensitivity and interference rejection characteristics varies very little with respect to the reader carrier frequency and whether the interferer signal is the LMS-5G BS downlink or UE uplink.

However the presence of adjacent carriers as would occur in multi-lane applications changes the wake-up level for some transponders (on average 1.5 dB wake-up change with the levels tested) and changes the interference/signal susceptibility ratio.

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Table 5-5: 6C Transponders Receive Susceptibility to LMS-5G Signals

Transponder ASIC	Test Case	Wake up level (dBm(i)) (4)	I/S at Wake (PER 5%) (dB)	I/S at Wake+7 dB (PER 5%) (dB)	I ratio (dB) for PER 5%-95% at Wake	I ratio (dB) for PER 5%-95% at Wake+7 dB
6C : Higgs3	TAG DL INTF	-12.5	-12.1	(1)	7.9 (2)	(1)
6C : M4E		-11.0	-9.8	-9.3	4.8	2.6
6C : M780		-15.9	-6.1	-3.9	4.5	2.7
6C : NXP 7XM		-15.3	-3.2	-3.3	2.4	2.3
6C : Higgs3	TAG DL INTF ADJ	-13.1	-11.2	(1)	7.4 (2)	(1)
6C : M4E		-12.8	-8.8	-10.3	4.0	2.9
6C : M780		-17.0	-10.8	-5.8	4.8	3.1
6C : NXP 7XM		-16.8	-6.6	-6.8	2.8	2.8
6C : Higgs3	TAG DL INTF NxtCH	-12.1	-12.7	(3)	8.2 (2)	(3)
6C : M4E		-10.3	-11.8		3.1	
6C : M780		-16.4	-5.0		3.9	
6C : NXP 7XM		-15.4	-3.0		2.5	
6C : Higgs3	TAG UL INTF	-12.2	-12.1	(1)	7.2 (2)	(1)
6C : M4E		-10.3	-12.0	-9.8	3.2	3.1
6C : M780		-16.3	-6.9	-4.4	3.1	3.3
6C : NXP 7XM		-15.6	-3.8	-3.9	2.3	2.6
6C : Higgs3	TAG UL INTF ADJ	-13.3	-12.5	(1)	8.5 (2)	(1)
6C : M4E		-11.3	-11.2	-10.1	3.6	3.4
6C : M780		-17.5	-11.1	-5.7	5.0	4.3
6C : NXP 7XM		-17.5	-6.0	-6.7	2.9	3.3
6C : Higgs3	TAG UL INTF NxtCH	-11.9	-12.6	(3)	7.2 (2)	(3)
6C : M4E		-11.1	-11.8		3.3	
6C : M780		-16.1	-6.8		3.9	
6C : NXP 7XM		-15.2	-4.4		2.4	

Note (1). Unable to determine these conditions. The Alien Higgs 3 transponder showed unusual behavior at high interference >80% PER when the signal plus 5G interference was present and the total average receive power at the transponder was around -3 dBm(i). However when only signal was present the transponder supported reader signal levels up to the limit of testing (+7 dBm).

Note (2). Approximate as the Alien Higgs 3 transponder showed rapid unusual behavior at high interference (>80% PER) when the signal plus 5G interference was present and the total receive power at the transponder was around -3 dBm(i).

Note (3). Not tested, these test cases were only performed at wake to see if transponders show improvement in susceptibility as interference frequency is shifted from reader carrier frequency.

Note (4) Actual wake-up is 0 to -1 dB below reported value – due to test set attenuator only 1 dB step size

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Table 5-6 lists the susceptibility of the single SeGo transponder tested. The sensitivity and interference rejection characteristics varies very little with respect to the reader carrier frequency and whether the interferer signal is the LMS-5G BS downlink or UE uplink.

However the presence of adjacent carriers such as would occur in multi-lane applications affected both the wake-up level and interference susceptibility.

Table 5-6: SeGo Transponder Receive Susceptibility to LMS-5G Signals

Test Case	Wake up level (dBm(i)) (2)	I/S at Wake (PER 5%) (dB)	I/S at Wake+7 dB (PER 5%) (dB)	I ratio (dB) for PER 5%-95% at Wake	I ratio (dB) for PER 5%-95% at Wake+7 dB
TAG DL INTF	-9.2	-6.6	-8.7	1.8	1.5
TAG DL INTF ADJ	-11.2	-5.6	-7.7	1.9	1.6
TAG DL INTF NxtCH	-8.2	-7.2	(1)	1.6	(1)
TAG UL INTF	-8.4	-7.4	-9.9	2.3	2.0
TAG UL INTF ADJ	-9.2	-6.7	-8.9	2.1	2.0
TAG UL INTF NxtCH	-8.9	-7.1	(1)	2.1	(1)

Note (1) Not tested, these test case were only performed at wake to see if transponders show improvement in susceptibility as interference frequency is shifted from reader carrier frequency

Note (2) Actual wake-up is 0 to -1 dB below reported value – due to test set attenuator only 1 dB step size

Table 5-7 shows the susceptibility of the TDMA transponders tested. Unlike TDM transponders these are susceptible to I/S ratio and not the absolute value of interference power.

Table 5-7: TDMA Transponders Receive Susceptibility to LMS-5G Signals

Transponder	Test Case	Wake up level (dBm(i)) (1)	I/S at Wake (PER 5%) (dB)	I/S at Wake+10 dB (PER 5%) (dB)	I ratio (dB) for PER 5%-95% at Wake	I ratio (dB) for PER 5%-95% at Wake+10 dB
TDMA : CVOST	TAG DL	-31.4	-3.3	-4.5	3.2	3.3
TDMA : TRP8100	INTF	-32.4	-4.0	-5.3	3.0	3.1
TDMA : CVOST	TAG UL	-31.4	14.4	12.9	3.2	3.3
TDMA : TRP8100	INTF	-32.4	15.4	14.0	3.3	3.5

Note (1) Actual wake-up is 0 to -1 dB below reported value – due to test set attenuator only 1 dB step size

During the transponder sensitivity tests, the transponder power levels at the reader were recorded for the same tag-reader losses that were set for reader-tag losses in the previous tables. These are listed in Table 5-8. These power levels have been converted into equivalent transponder EIRP levels in Table 5-9. This shows that the presence of adjacent carriers at the transponder has a detrimental effect on the effective EIRP from the passive transponder. Because of this sensitivity, the EIRP will also be affected by the interference power received by the passive transponders, but this was not measured.

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Table 5-8: Transponder Signal Levels recorded at Reader During Transponder Susceptibility Tests

Transponder	Test Case	Reader (MRFMSP)		+7 vs Wake Transponder power change after path loss corrected
		dBm at wake	dBm at wake+7	
TDM : G4E	(2)	-58.9	-51.9	0
TDM : HOT		-58.7	-51.7	0
TDM : G5		-57.9	-50.9	0
TDM : FME		-57.2	-50.2	0
TDMA : CVOST		-68.7	-58.7 (1)	0
TDMA : TRP8100		-68.7	-58.7 (1)	0
6C : Higgs3	TAG DL INTF	-64.8	-55.7	2.1
6C : M4E		-61.2	-51.6	2.6
6C : M780		-68.2	-54.5	6.7
6C : NXP 7XM		-68.0	-56.5	4.5
6C : Higgs3	TAG DL INTF ADJ	-67.3	-58.0	2.3
6C : M4E		-67.1	-59.5	0.6
6C : M780		-69.7	-57.3	5.4
6C : NXP 7XM		-72.1	-61.2	3.9
6C : Higgs3	TAG UL INTF	-64.1	-55.1	2.0
6C : M4E		-61.4	-49.6	4.8
6C : M780		-67.5	-54.3	6.2
6C : NXP 7XM		-67.1	-56.2	3.9
6C : Higgs3	TAG UL INTF ADJ	-66.3	-56.5	2.8
6C : M4E		-63.2	-51.7	4.5
6C : M780		-69.8	-57.0	5.8
6C : NXP 7XM		-71.4	-60.4	4.0
SeGo	TAG DL INTF	-62.5	-47.3	8.2
	TAG DL INTF ADJ	-66.7	-52.0	7.7
	TAG UL INTF	-60.2	-46.5	6.7
	TAG UL INTF ADJ	-62.7	-48.7	7.0

Note (1) with +10 dB on path loss.

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Table 5-9: Transponder Effective EIRP and Susceptibility to Reader Power

Transponder	Test Case	Effective EIRP (1) at Wake (dBmi)	Effective EIRP at Wake +7 dB (dBmi)
TDM : G4E	(2)	-10.9	(2)
TDM : HOT		-10.8	
TDM : G5		-9.9	
TDM : FME		-4.1	
TDMA : CVOST		-0.2	
TDMA : TRP8100		0.8	
6C : Higgs3	TAG DL INTF	-16.7	-14.6
6C : M4E		-16.1	-11.5
6C : M780		-16.1	-9.4
6C : NXP 7XM		-16.9	-12.5
6C : Higgs3	TAG DL INTF ADJ	-18.2	-15.9
6C : M4E		-18.0	-13.5
6C : M780		-16.6	-11.2
6C : NXP 7XM		-19.1	-15.1
6C : Higgs3	TAG UL INTF	-16.0	-14.1
6C : M4E		-15.4	-10.5
6C : M780		-15.4	-9.3
6C : NXP 7XM		-16.0	-12.1
6C : Higgs3	TAG UL INTF ADJ	-17.2	-14.4
6C : M4E		-16.1	-11.6
6C : M780		-16.8	-11.0
6C : NXP 7XM		-18.3	-14.3
SeGo	TAG DL INTF	-17.4	-9.2
	TAG DL INTF ADJ	-19.6	-11.9
	TAG UL INTF	-16.1	-9.5
	TAG UL INTF ADJ	-17.7	-10.6

Note (1) For common link budget usage herein, EIRP is expressed as the average radiated power of the modulated transponder signal over the transmission burst at elevation and azimuth 0 degrees. TDM [AD3] and TDMA EIRP is normally specified as Peak ON power. 6C transponder reflected modulation power is normally specified [AD8] in terms of backscatter range. SeGo transponder reflected modulation power is normally specified [AD6] in terms of conversion factor.

Note (2) TDM and TDMA transponders self-generate their transmission to readers and this is not affected by the receive signal or interference levels.

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5.3 TDM Write vs TDM Read

Because the Kapsch readers only write to a transponder when the stored data needs changed, and production transponders have fixed serial numbers, it is not easy to determine the difference in write probability compared to read only probability with a reader. In the absence of interference, the Kapsch reader will always send the first write to the transponder in the frame containing the second successful read of the transponder, and if the write was successful (determined in same frame as the write) the reader will stop attempting to write to the transponder. If the write was not successful the reader will continue to send the write on subsequent frames that have successful reads of the transponder.

To determine this TDM Write probability in the laboratory, the technique used by Kapsch was:

- Specially modify a G4 series transponder to automatically change its Serial Number whenever a TDM reader write is accepted by the transponder;
- Capturing the raw handshake reports from the reader to the lane controller which contain the successful raw handshakes for each successful read and write; and
- Analyze the read and write success rates from the raw handshake reports.

Thus 2 data sets result:

- Packet error rate of Read – determined using successful reads versus protocol frames
- Added packet error rate of Write – determined using the success rate of writes in handshakes that have a successful read.

The results were that the Writes were more susceptible to approximately 2 dB lower base station interference, and 3 dB lower UE interference, than Reads for the same packet error rate.

5.4 Transponder Circuit Current Susceptibility

NextNav previously stated *“As some commenters note, however, potential interference via mobile devices to the transponders (scenario 4) could result in faster depletion of battery life due to increased, unintended wakeups outside of a toll plaza area if the proposed network is deployed. Based on NextNav’s analysis, this theoretical concern seems unlikely to pose a serious challenge because reader pulses and 5G NR bands are widely different waveforms; however testing promises to provide clear answers and offer concrete solutions”*³⁷, yet NextNav provided no analysis to justify their statement and failed to perform any testing when they decided to conduct their own coexistence study.

Note in fact the higher power of the base stations can affect the life of the transponders, as shown later in the coexistence analysis.

The TDM and TDMA transponders are battery powered and the circuits are normally operated under very low current consumption to achieve long life. The Kapsch TDM transponders have RF filtering to protect against signals outside the 909.75-921.75 MHz sub-band; in particular against the 800 MHz cellular band (at 894 MHz and lower). However interference very close to the operating frequency will pass through the hardware receive filters and cause currents to increase in the circuitry.

The TDM transponders show increase in current based on both detector biasing from the interference and false transponder responses. The false responses occur when the random time domain of the LMS-5G signal (see Figure 4-12) reaches a level where the interference is detected as valid trigger pulses and the tag transmits a response. This only occurs over window of I/S about 3 dB wide as demonstrated for the HOT transponder in Figure 5-1.

³⁷ Page 53, “Reply Comments of NextNav Inc.”, NextNav correspondence to FCC Secretary under docket 24-240, dated Sept 20 2024

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Figure 5-2 shows the false responses occurring in time at two Interference/Wake levels. Note that this false response triggering, if present in the ETC zone, can cause interference to the reception of other protocols, for example other protocol transponders in the same vehicle and at the reader.

Figure 5-1 shows the impact of the interference to a HOT transponder currents. Idle current is the normal standby current drained from the battery. The interference impacts the currents as follows:

- The current increases to 1.5x idle when the interference reaches ~ -6 dB for DL, ~ +2 dB for UL, relative to the transponder wake-up threshold. This interference level is referred to as “1.5x point”.
 - Note there are impacts with interference signal levels below the 1.5X point as can be seen in the figure, but this point was selected for coexistence analysis purposes as the current increase rises rapidly above this point.
- The current increases beyond this “1.5x point” to 23x idle current for ~ 8 dB increase in interference power above that “1.5x point”.
- The false response region starts at interference power ~ 9 dB above the “1.5x point” and extends to ~ 12 dB above that “1.5x point”. During the false response region, the current peaks at > 1000x idle current.
- Above the false response region the current remains at 23x the idle current.

This HOT interference-current characteristic is also valid for the G4 series transponders as these all have similar receive circuitry.

Figure 5-3 shows the impact of the interference to a FME transponder currents. Only the DL current is shown as the susceptibility to LMS-5G UL interference is >16 dB better than against LMS-5G DL and the test system was unable to cause noticeable current increases. The interference impacts the FME currents as follows:

- The current increases to 1.5x idle when the DL interference reaches ~ -3 dB relative to the wake-up threshold.
- It increases beyond this “1.5x point” to 23x idle for ~ 6 dB increase above that “1.5x point”.
- The false response region starts at ~ 7 dB above the “1.5x point” and extends to ~10 dB above that “1.5x point” point. During the false response region the current peaks at > 1000x idle current.
- Above the false response region the current remains at 23x the standby current.

Figure 5-4 shows the impact of the interference to a G5 transponder currents. The interference impacts the G5 currents as follows:

- The current increases to 1.5x idle when the DL interference reaches ~ -1 dB relative to the wake-up threshold.
- The false response region starts at ~ 1 dB above the “1.5x point” and extends to ~ 5.5 dB above that “1.5x point”. During the false response region, the current peaks at > 800x idle current.
- Above the false response region the current remains at ~1.5x the standby current.

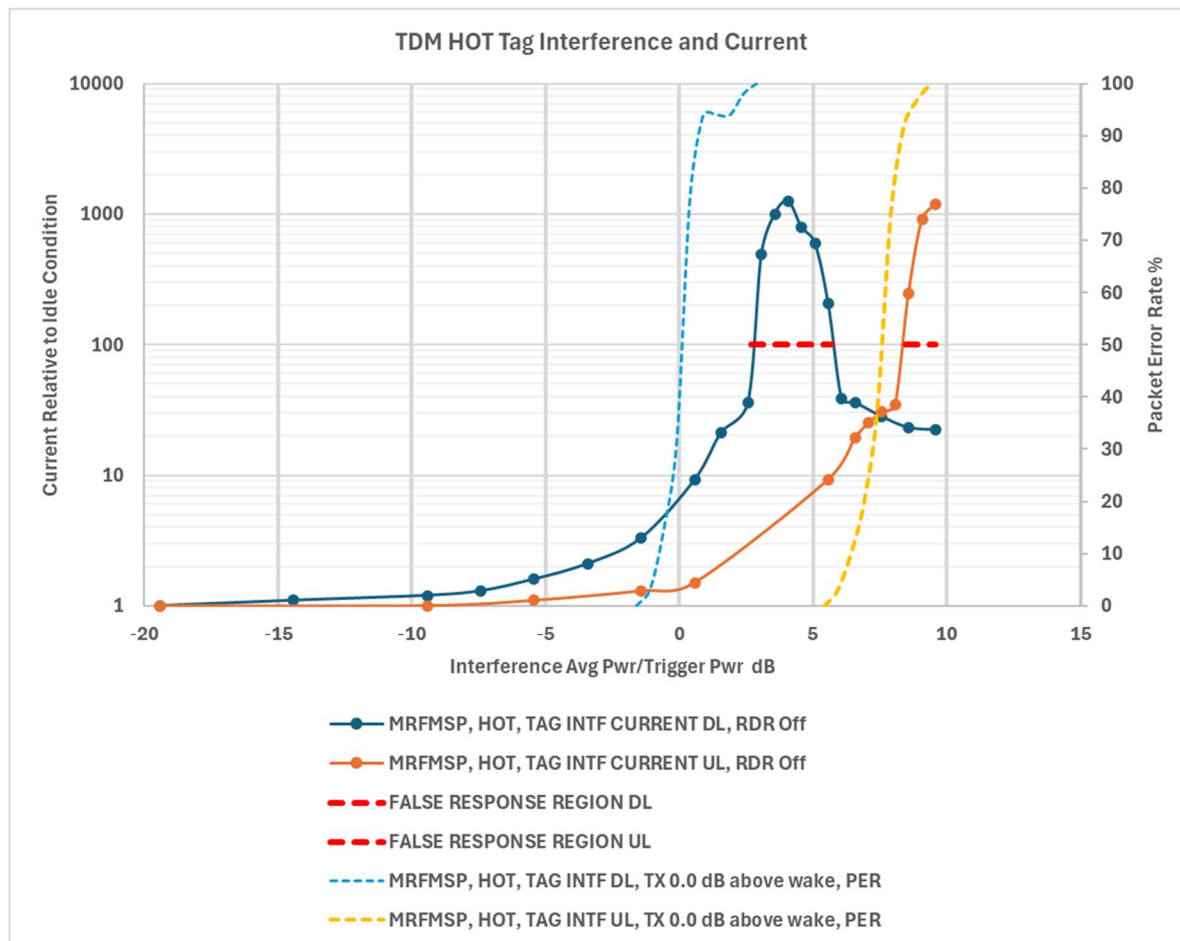
TDMA transponders have completely different circuitry than TDM transponders and the current characteristics are shown in Figure 5-5. The interference impacts the TDMA currents as follows:

- The current remains at the Idle currents until the interference reaches ~ +3 dB for DL, ~ +23 dB for UL, relative to the wake-up threshold.
- At interference levels above these, the TDMA currents are ~ 300x the idle currents. This characteristic is applicable for both the TRP-8100 and CVOST transponders. Note TDMA transponders do not exhibit false transponder responses.

The above current characteristics can be used for analysis of the impact on life of the transponders which is driven in each transponder by the idle current and battery capacity.

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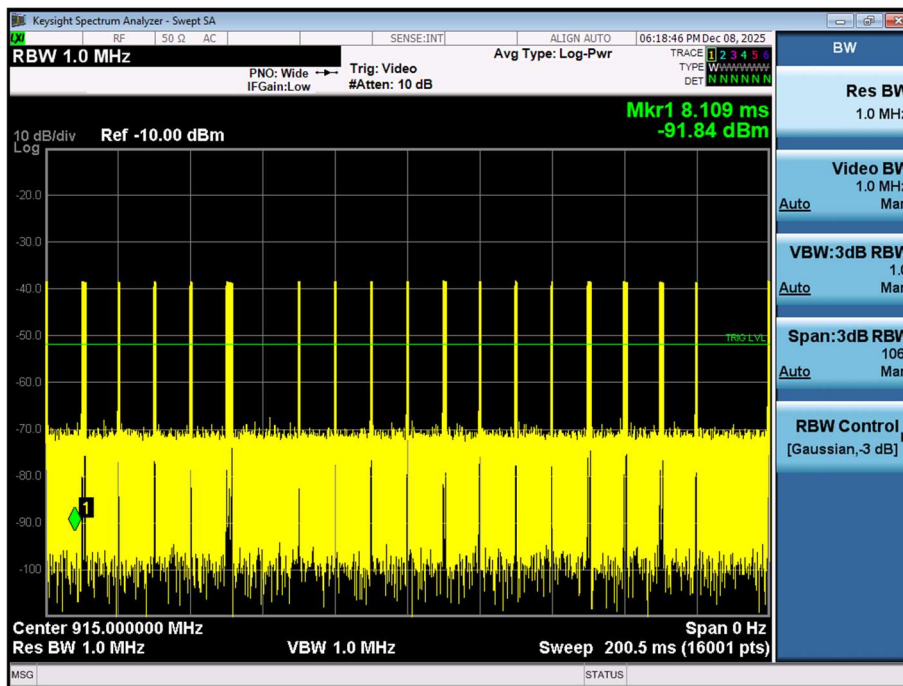
Figure 5-1: TDM HOT Tag Current Impact Due to LMS-5G Interference



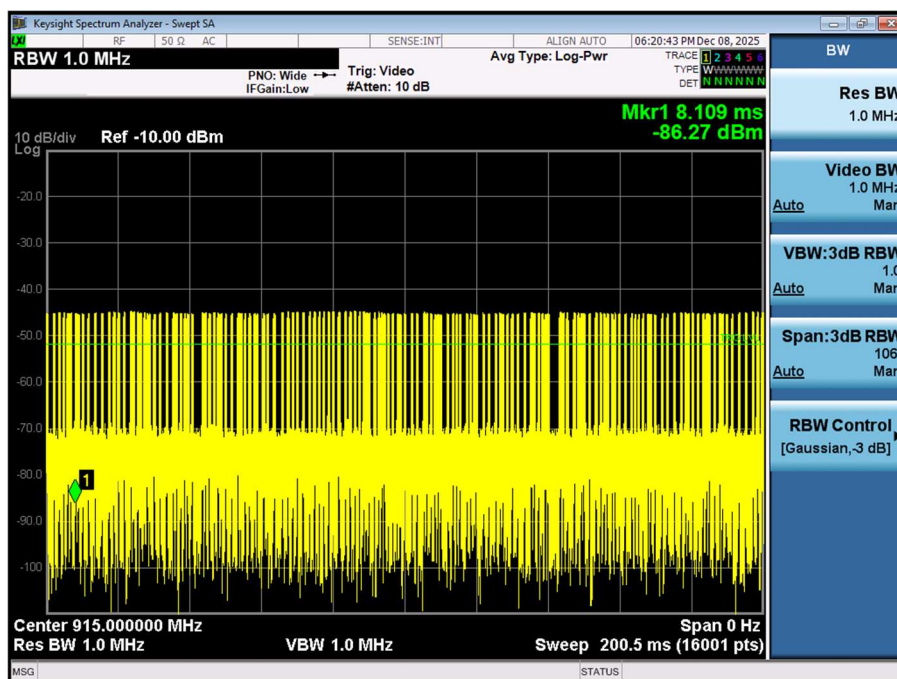
Note : LMS-5G UL interference data was limited to about 11 dB above the wake-up level of the transponder, due to limitations of interference power in the test set. The current characteristic vs UL Interference/trigger ratio is expected to follow the characteristic exhibited for DL interference.

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Figure 5-2: TDM Tag False Triggers due to LMS-5G Interference



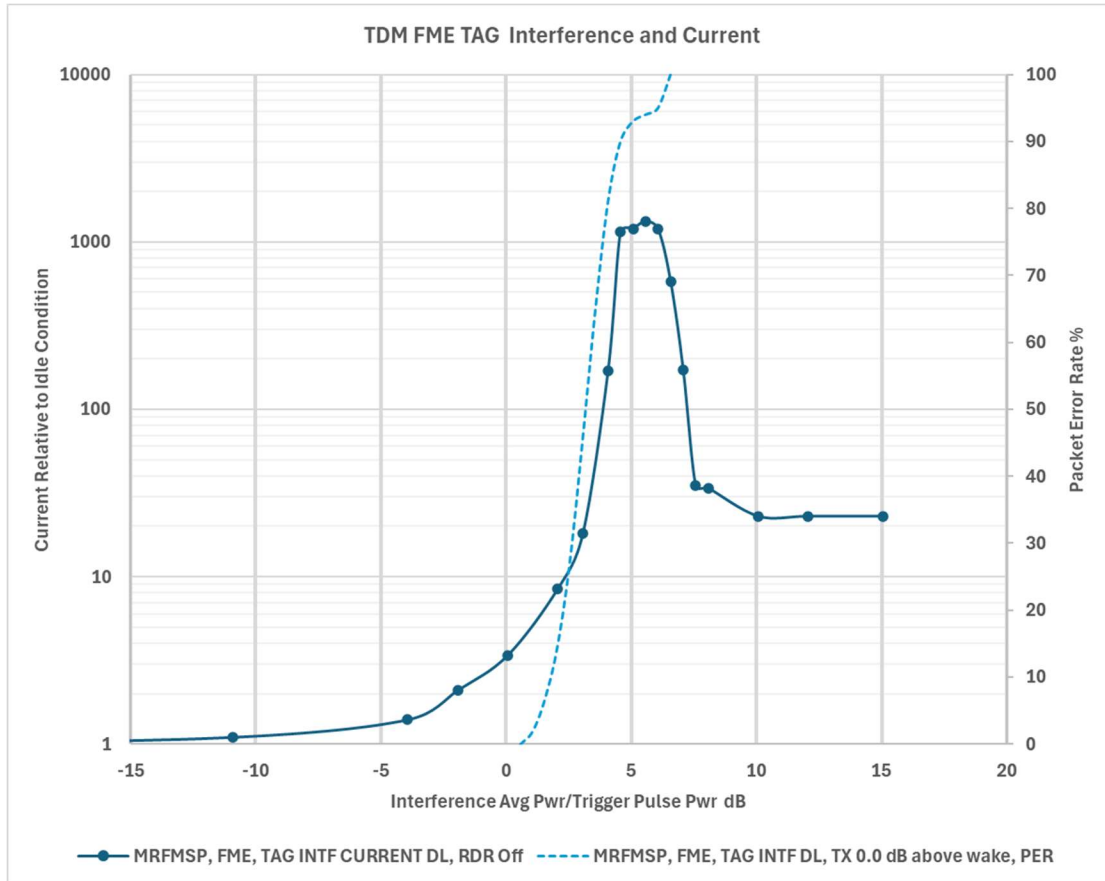
At ~3 dB above Wake



At ~5 dB above Wake

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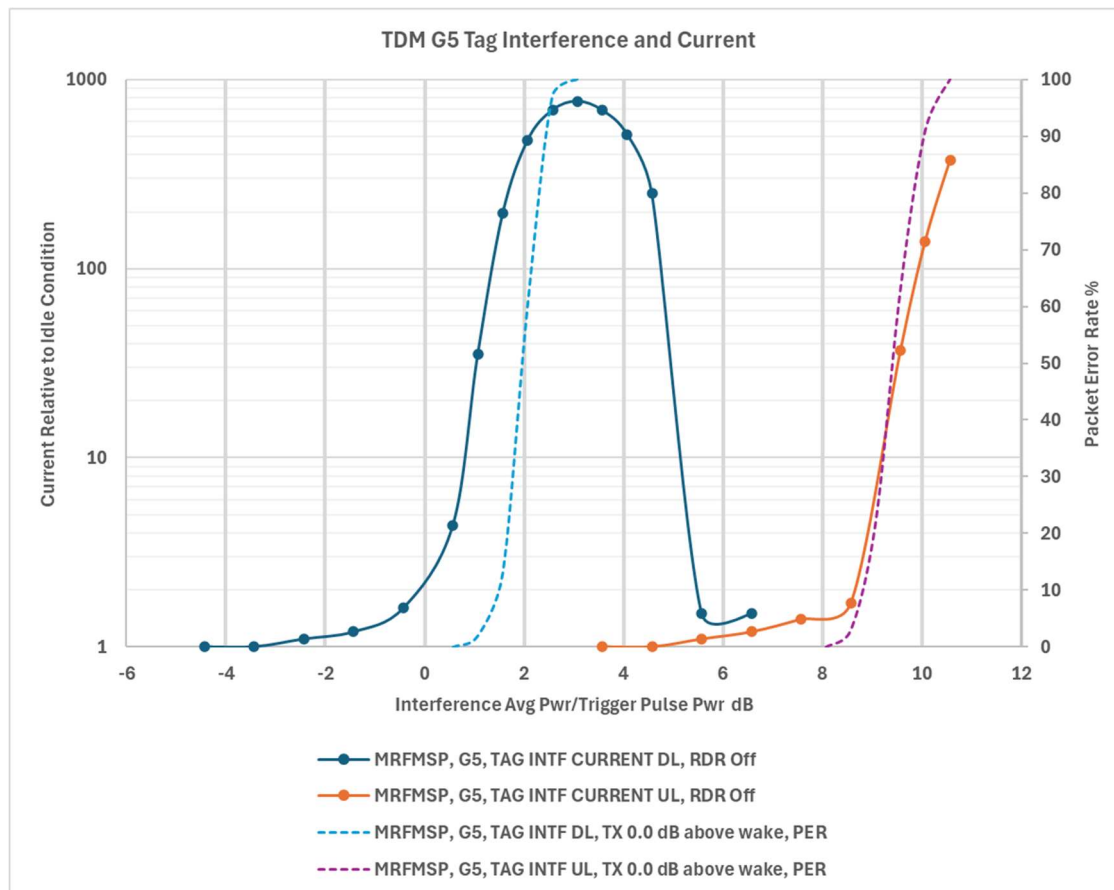
Figure 5-3: TDM FME Tag Current Impact due to LMS-5G Interference



Note only LMS-5G DL interference characteristics are shown, as the test system was unable to reach a level where LMS-5G UL interference affected the FME.

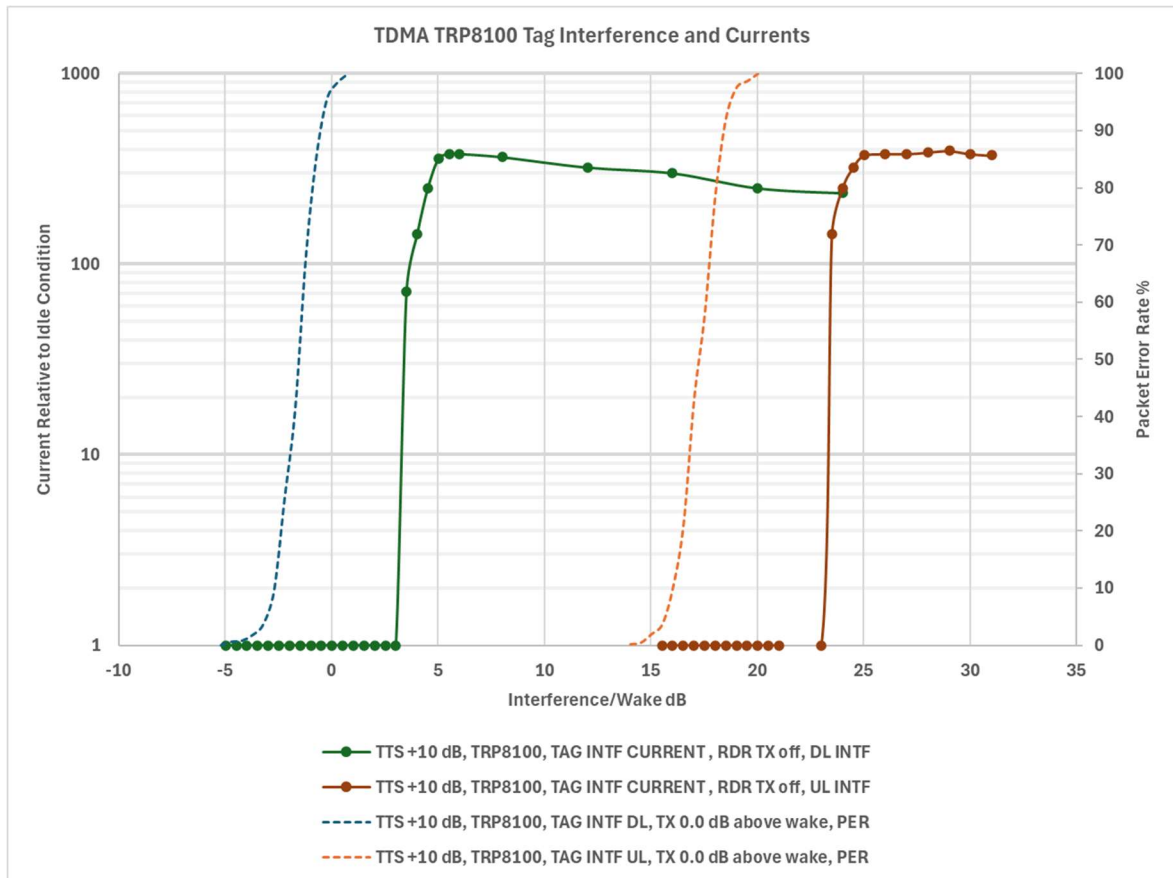
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Figure 5-4: TDM G5 Tag Current Impact due to LMS-5G Interference



Note the LMS-5G UL interference level was limited to around 11 dB above the wake-up level of the transponder, due to limitations of interference power in the test set. The current characteristic vs UL Interference/trigger ratio is expected to follow the characteristic exhibited for DL interference.

Figure 5-5: TDMA Tag Current Impact due to LMS-5G Interference



5.5 Reader Data Recovery Susceptibility

For testing reader susceptibility, it is not necessary to test every transponder, since the interference handling characteristics are primarily dependent on interference/signal ratio at the reader. Thus reader susceptibility was measured with only one transponder model of each protocol type. The reader downlink was set to 1 dB above wake to ensure the tag did not have issues responding during the tests, yet minimize the impact of changing backscatter power vs incident power for passive transponders. Interference and adjacent channel signals were only injected on the uplink.

Table 5-10 indicates the transponder levels at the MRFMS radio input recorded in the test and Table 5-12 records the susceptibility of the MRFMS in terms of interference power. Table 5-12 expresses the data in terms of Interference/signal ratio.

Similarly Table 5-13, Table 5-14 and Table 5-15 record the same information for the MRFMSP.

Note the MRFMSP has ~3 dB more TX power than the MRFMS and can tolerate longer cable lengths. Since the RX test path loss was set equal to the TX test path loss, the uplink signals at the reader in the MRFMSP test are lower in Table 5-13 than in Table 5-10, and similarly Table 5-14 versus Table 5-11.

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Some key observations are:

- The MRFMS and MRFMSP were not designed to significantly reject interference for the TDM protocol at 918 MHz resulting in the poor RDR DL INTF rejection characteristics.
 - Note that the MRFMS TDM receiver is similar to the receivers used in radios at the time of the previous interference assessment against the Progeny system, which transmits on frequencies above 919.75 MHz.
 - The TDM transponders mostly have 99% emission bandwidths in excess of 7 MHz and reader receivers were designed to recover these signals. Even the transponder 20 dB bandwidth exceeds 5 MHz (e.g. JQU 801660B). With a maximum CF of 915.5 MHz plus >2.5 MHz half 20 dB bandwidth the upper frequency to be recovered can exceed 918 MHz.
- The MRFMSP has better interference rejection than the MRFMS.
- The MRFMS is not very sensitive to the channel frequency offset from the band edge, nor the presence of adjacent carrier levels at the reader. Hence all channels in the frequency plan channel will be affected by same level of base station interference.
- The MRFMS TDM susceptibility is constant irrespective of received transponder power.
- The MRFMSP channel frequencies at 1.5 MHz from edge of sub-band are 15 dB more susceptible for 6C than channel frequencies at 2.0 MHz from edge of sub-band. Other than that, the MRFMSP is not very sensitive to the channel frequency offset from the band edge, nor the presence of adjacent carrier levels at the reader. Note that with 2 MHz from both sub-band edges, the required 4 channel frequency plan will require 11.5 MHz of spectrum allocation, more than NextNav proposed for the NM-LMS-Prop sub-band.

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Table 5-10: Transponder signal levels at MRFMS recorded in Reader Susceptibility Test

Transponder	Test Cases	Transponder Signal level at Reader at Wake Path Loss (dBm)	Transponder Signal level at Reader at Wake +7 dB Path Loss (dBm)
TDM – G4E	RDR DL INTF , RDR UL INTF	-53.7	-46.7
6C : Higgs3	RDR DL INTF	-60.0	-50.9
	RDR DL INTF ADJ		
	RDR DL INTF 0.5 m	-60.0	(1)
	RDR DL INTF NxtCH	-60.0	(1)
SeGo	RDR DL INTF	-57.2	-43.1
	RDR DL INTF ADJ		
	RDR DL INTF 0.5 m	-57.2	(1)
	RDR DL INTF NxtCH	-56.8	(1)
6C : Higgs3	RDR UL INTF	-59.6	-50.6
	RDR UL INTF ADJ		
	RDR UL INTF 0.5 m	-57.9	(1)
	RDR UL INTF NxtCH	-57.9	(1)
SeGo	RDR UL INTF	-56.2	-42.8
	RDR UL INTF ADJ		
	RDR UL INTF 0.5 m	-56.2	(1)
	RDR UL INTF NxtCH	-56.8	(1)

Note (1). Not tested, these test cases were only performed at wake to see if transponders show improvement in susceptibility as reader carrier frequency is shifted away from carrier frequency closest to band edge.

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Table 5-11: MRFMS Susceptibility Interference Level for LMS-5G Signals

Transponder	Test Cases	Interference Level (dBm) at Reader for 5% PER at RX = Wake path loss	I Interference Level (dBm) at Reader for 5% PER at RX =Wake path loss – 7 dB	-7 to Edge path, Change after path loss corrected
TDM – G4E	RDR DL INTF	-65.4	-64.7	-6.3
6C : Higgs3	RDR DL INTF	-11.6	-6.6	-2.0
	RDR DL INTF ADJ	-12.0	-6.8	-1.8
	RDR DL INTF 0.5 m	-10.6	(1)	
	RDR DL INTF NxtCH	-9.4	(1)	
SeGo	RDR DL INTF	-5.6	-1.0	-2.4
	RDR DL INTF ADJ	-6.3	-1.3	-2.0
	RDR DL INTF 0.5 m	-4.9	(1)	
	RDR DL INTF NxtCH	-5.0	(1)	
TDM – G4E	RDR UL INTF	-29.6	-28.9	-6.3
6C : Higgs3	RDR UL INTF	-14.5	-9.2	-1.4
	RDR UL INTF ADJ	-15.1	-9.4	-1.5
	RDR UL INTF 0.5 m	-14.1	(1)	
	RDR UL INTF NxtCH	-13.0	(1)	
SeGo	RDR UL INTF	-9.8	-4.0	-1.2
	RDR UL INTF ADJ	-10.1	-4.1	-1.0
	RDR UL INTF 0.5 m	-8.5	(1)	
	RDR UL INTF NxtCH	-7.5	(1)	

Note (1). Not tested, these test case were only performed at wake to see if transponders show improvement in susceptibility as reader carrier frequency is shifted away

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Table 5-12: MRFMS Susceptibility Interference/Signal Ratio for LMS-5G Signals

Transponder	Test Cases	I/S Level (dB) at Reader for 5% PER at RX = Wake path loss	I/S Level (dB) at Reader for 5% PER at RX =Wake path loss – 7 dB	I ratio (dB) for PER 5%-95% at RX =Wake path loss	I ratio (dB) for PER 5%-95% at RX =Wake path loss – 7 dB
TDM – G4E	RDR DL INTF	-11.6	-18.0	2.6	5.3
6C : Higgs3	RDR DL INTF	48.4	44.3	3.2	12.7
	RDR DL INTF ADJ	48.0	44.1	2.8	2.4
	RDR DL INTF 0.5 m	49.4	(1)	2.9	(1)
	RDR DL INTF NxtCH	50.6	(1)	3.0	(1)
SeGo	RDR DL INTF	51.2	41.7	2.3	2.2
	RDR DL INTF ADJ	50.6	41.6	2.3	2.0
	RDR DL INTF 0.5 m	52.1	(1)	1.9	(1)
	RDR DL INTF NxtCH	51.3	(1)	2.3	(1)
TDM – G4E	RDR UL INTF	24.1	17.8	2.8	5.1
6C : Higgs3	RDR UL INTF	45.1	41.4	3.0	2.7
	RDR UL INTF ADJ	44.5	41.2	3.1	2.7
	RDR UL INTF 0.5 m	43.7	(1)	2.8	(1)
	RDR UL INTF NxtCH	44.8	(1)	3.1	(1)
SeGo	RDR UL INTF	45.7	38.2	3.0	2.7
	RDR UL INTF ADJ	45.1	38.1	3.2	3.0
	RDR UL INTF 0.5 m	47.1	(1)	2.7	(1)
	RDR UL INTF NxtCH	48.6	(1)	2.8	(1)

Note (1). Not tested, these test cases were only performed at wake to see if transponders show improvement in susceptibility as reader carrier frequency is shifted away from carrier frequency closest to band edge.

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Table 5-13: Transponder Signal Levels at MRFMSP Recorded in Reader Susceptibility Test

Transponder	Test Cases	Transponder Signal level at Reader at RX=Wake Path Loss (dBm)	Transponder Signal level at Reader at RX=Wake -7 dB Path Loss (dBm)
TDM – G4E	RDR DL INTF , RDR UL INTF	-57.9	-50.9
6C : Higgs3	RDR DL INTF RDR DL INTF ADJ	-63.8	-54.9
	RDR DL INTF 0.5 m RDR DL INTF 0.5 m ADJ	-63.1	(1)
	RDR DL INTF NxtCH	-64.1	(1)
SeGo	RDR DL INTF RDR DL INTF ADJ	-58.3	-45.1
	RDR DL INTF 0.5 m	-62.2	(1)
6C : Higgs3	RDR UL INTF RDR UL INTF ADJ	-62.9	-54.1
	RDR UL INTF 0.5 m RDR UL INTF 0.5 m ADJ	-63.2	(1)
	RDR UL INTF NxtCH	-63.3	(1)
SeGo	RDR UL INTF RDR UL INTF ADJ	-59.1	-45.3
	RDR UL INTF 0.5 m	-59.4	(1)

Note (1). Not tested, these test case were only performed at wake to see if transponders show improvement in susceptibility as reader carrier frequency is shifted away from carrier frequency closest to band edge.

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Table 5-14: MRFMSP Susceptibility Interference Level for LMS-5G Signals

Transponder	Test Cases	Interference Level (dBm) at Reader for 5% PER at RX = Wake path loss	I Interference Level (dBm) at Reader for 5% PER at RX =Wake path loss – 7 dB	-7 to Edge path, Change after path loss corrected
TDM – G4E	RDR DL INTF	-62.9	-55.5	0
6C : Higgs3	RDR DL INTF	-30.3	-18.4	4.9
	RDR DL INTF ADJ	-30.7	-18.0	5.7
	RDR DL INTF 0.5 m	-15.7	(1)	
	RDR DL INTF 0.5 m ADJ	-14.4	(1)	
	RDR DL INTF NxtCH	-13.3	(1)	
SeGo	RDR DL INTF	-3.3	3.8	0.1
	RDR DL INTF ADJ	-3.8	3.3	0.1
	RDR DL INTF 0.5 m	-5.8	(1)	
TDM – G4E	RDR UL INTF	0.0	3.4	-3.6
6C : Higgs3	RDR UL INTF	-30.3	-22.8	1.5
	RDR UL INTF ADJ	-30.6	-20.5	3.1
	RDR UL INTF 0.5 m	-14.9	(1)	
	RDR UL INTF 0.5 m ADJ	-15.5	(1)	
	RDR UL INTF NxtCH	-14.2	(1)	
SeGo	RDR UL INTF	-4.6	1.4	-1.0
	RDR UL INTF ADJ	-4.9	1.0	-1.0
	RDR UL INTF 0.5 m	-4.9	(1)	

Note (1). Not tested, these test case were only performed at wake to see if transponders show improvement in susceptibility as reader carrier frequency is shifted away

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Table 5-15: MRFMSP Susceptibility Interference/Signal Ratio for LMS-5G Signals

Transponder	Test Cases	I/S Level (dB) at Reader for 5% PER at RX=Wake path loss	I/S Level (dB) at Reader for 5% PER at RX=Wake path loss -7 dB	I ratio (dB) for PER 5%- 95% at RX=Wake path loss	I ratio (dB) for PER 5%-95% at RX=Wake path loss-7 dB
TDM – G4E	RDR DL INTF	-5.0	-4.6	3.5	2.8
6C : Higgs3	RDR DL INTF	33.5	36.5	4.3	4.4
	RDR DL INTF ADJ	33.0	36.8	6.7	4.1
	RDR DL INTF 0.5 m	47.4	(1)	3.2	(1)
	RDR DL INTF 0.5 m ADJ	48.8	(1)	3.0	(1)
	RDR DL INTF NxtCH	50.8	(1)	3.1	(1)
SeGo	RDR DL INTF	54.1	48.3	4.9	2.5
	RDR DL INTF ADJ	53.2	47.9	5.7	3.0
	RDR DL INTF 0.5 m	56.2	(1)	1.8	(1)
TDM – G4E	RDR UL INTF	57.9	54.3	6.0	2.7
6C : Higgs3	RDR UL INTF	32.6	31.3	4.9	4.9
	RDR UL INTF ADJ	32.2	33.9	4.6	4.7
	RDR UL INTF 0.5 m	48.4	(1)	3.7	(1)
	RDR UL INTF 0.5 m ADJ	47.8	(1)	3.8	(1)
	RDR UL INTF NxtCH	49.1	(1)	2.7	(!)
SeGo	RDR UL INTF	53.8	46.0	3.4	3.4
	RDR UL INTF ADJ	53.2	45.9	4.3	3.8
	RDR UL INTF 0.5 m	54.1	(1)	2.6	(1)

Note (1). Not tested, these test cases were performed at wake to see if transponders show improvement in susceptibility as reader carrier frequency is shifted away from carrier frequency closest to band edge.

6. COEXISTENCE ANALYSIS

Ideally a coexistence analysis would prove that there is no need for the LMS-5G and AVI community to have to coordinate with each other on site locations, other than perhaps an agreed minimum physical separation between sites of the 2 systems and as long as the performance metrics for both systems are met at and above that distance for all instances then there is no coexistence risk.

Kapsch approaches this from the perspective of 2 stages of analysis:

- The first stage assesses whether there are any cases of not meeting performance at any site under worst azimuth orientations, full power transmit, 100% duty cycle and mean of statistical parameters. If this is satisfied with margin then there is no need for coordination.
 - If the BS-AVI device minimum susceptibility distance is greater than the cell radius of any site of the LMS-5G wireless communication system, then the likelihood of Coexistence is extremely low.
 - If not then the analysis is extended over a range of ground distance to see if there can be any issues that may require second stage assessment.
- The second stage was performed only for BS to transponder cases and was introduced to verify if statistics support the first stage assessment that coexistence risks exist by evaluating the probability of BS-AVI locations sites having such issues, including assuming random relationships between LMS-5G equipment and the AVI equipment as well as the other statistical parameters.

Kapsch does not include the modelling of base station loading and traffic activity nor power control of the UEs in the analysis (see also section 6.2.6).

NextNav state they “*treat all of the statistical quantities using a median or average value, as is commonly done in link budget analyses,*” *In re Use of the 5.850-5.925 GHz Band, First Report and Order, Further Notice of Proposed Rulemaking, and Order of Proposed Modification, 35 FCC Rcd 13,440, 13,471 ¶ 74 (2020).*³⁸ in their modelling. This reference and the associated 6GHz footnote to which it points were discussing the interference from unlicensed devices, which have random power levels and placement, to the incumbent services. However the NextNav simulations were based off very limited (and non-representative) device data, fixed antenna characteristics and some specific geographic locations rather than a generalized model.

In this application we are dealing with interference from licensed services to licensed service, and effectively the analysis required is for fixed location sources to fixed location receivers for sites and mobile receivers for battery life and it will be too late to find out there is an issue later, given the complexity and expense caused by the proposed band change. Also it is not just enough to consider the deployment of LMS-5G against current deployed AVI systems, but also we need to consider the future deployment of AVI systems if LMS-5G is already deployed. For this reason a more general assessment is required rather than looking at specific geographic sites and drawing conclusions about this being representative for nationwide deployment of LMS-5G.

For the ETC community, our concern is that each toll site has to meet the performance of >99.95% identifying transponders. Some systems require much higher performance than this, and very little can be allocated for the contributions of LMS-5G interference. There are too many variables contributing to this (e.g. see sections 4.2.1 and 6.2.1, so the 5% PER interference threshold at wake-up was used in the Kapsch analysis.

Using a worst case stack-up of parameters will overestimate the probability of not meeting performance at any site. However just using the median or average of all statistical variables, and assigning the probability to only one variable is also not appropriate.

Any analysis involving statistical variables should combine the medians or averages linearly, and combine the standard deviations using the appropriate method (e.g. using root mean square if they are normal) to result in the overall probability distribution. Then this can be used along with the mean to determine the probability that the interference target will be satisfied over all sites.

³⁸ Footnote 51, page 10, [RD16], NextNav response Jan15, 2026

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A key problem is that not all the contributing variables are quantified. Instead herein, some assumptions are made, including assigning means and standard deviations, to be able to get an approximate view of whether there will be a need for coexistence coordination. Note the results therefore have some uncertainty and only field testing with real-world vehicle distributions can validate this analysis.

The analysis is based on the following for base station interference :

- The 3GPP maximum acceptable path loss (MAPL) is determined from the NextNav / Verizon data on the 5G system to close the wireless communication BS-UE links in NLOS conditions. MAPL is the value of PL as per 3GPP path modelling for the scenario to close the link.
 - PL equates to a ground distance d2d in those models.
 - d2d represent the nominal cell radius in the wireless BS deployment.
 - The link margins differ by path model (shadow fading principally).
- The 3GPP minimum required path loss PL (MRPL) to prevent the interference degrading the AVI system is determined, based on the susceptibility numbers determined for the AVI devices in Section 5 and the NextNav indicated typical BS EIRP.
 - Note the loss margin factors that apply for the BS-AVI device link are different to those for the BS-UE link.
- The MRPL for BS-AVI is compared to the MAPL for BS-UE, to indicate if coexistence is even possible at the cell radius.
- For those cases where it is possible at the cell radius, then the PL versus ground distance is analyzed to determine where in the cell radius range the MRPL could be violated.
- A second stage of analysis factors in the variations in pointing angles and other statistical variables like shadow fading to determine the probability that with random BS and AVI site deployments, sites will have an issue.

For the LMS-5G User Equipment to reader or transponder coexistence can be broken down into :

- If the AVI device is immune to the interference, then the likelihood of Coexistence is very high.
- If not then the probability of interfering will determine the magnitude of the coexistence problem. Note that the probability of interfering (UE power CCDF and activity factors) are still items of contention between the ETC community and NextNav.

The analysis in this section is based on the following for User Equipment interference:

- The minimum path losses required from the UE to the AVI devices are computed based on the UE max power and the AVI devices susceptibility.
- The separation distances required between the UE and AVI devices are determined using the applicable path model.
- If the separation distance is above a reasonable amount, then the probability of UE emissions being at that power and activity factors needs to be assessed, but this is not done in this report.

The key results for the analysis are summarized in Table 6-1. The conclusions drawn from this data are reported in section 7.

The details of the modelling used and the rationale behind values used are discussed in the following sub-sections.

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Table 6-1: Summary of First Stage Modelling Results

Source	Device	Protocol	Key points
BS 66 dBm EIRP d2d min set as 100 m	Reader	TDM	Issues up to 5280 m LOS and 1020 m NLOS Worst 40.9 dB above threshold
		6C	Issues up to 336 m LOS, worst 8.9 dB above threshold No NLOS issues min margin 5.7 dB
		SeGo	No issues, min margin 15.1 dB
	Transponder	TDM	No issues min margin 1.7 dB
		6C	Issues up to 498 m LOS, worst 8.3 dB above threshold No NLOS issues min margin 5.5 dB
		TDMA	Issues up to 1163 m LOS and 270 m NLOS, worst 18.8 dB above threshold
UE 23 dBm EIRP d2d min set at 0.2 m	Reader	TDM	Issues up to 7.4 m, worst 20.6 dB above threshold
		6C	Issues up to 8.0 m, worst 22.6 dB above threshold
		SeGo	Issues up to 3.0 m, worst 4.6 dB above threshold
	Transponder	TDM	Issues up to 0.3 m, worst 2.3 dB above threshold
		6C	Issues up to 4.0 m, worst 19.3 dB above threshold
		TDMA	Issues up to 1.3 m, worst 11.3 dB above threshold
BS as above d2d min set at 10 m UE as above d2d min set at 0.2 m	Transponder	TDM currents	Issues up to 179 m LOS and 16 m NLOS, worst 8.8 dB above threshold
		TDMA currents	Issues up to 722 m LOS and 89 m NLOS, worst 18.8 dB above threshold
		TDM currents	Issues up to 0.5 m, worst 5.3 dB above threshold
		TDMA currents	Issues up to 0.3 m, worst 2.3 dB above threshold

6.1 Interference Scenarios

In this study only the LMS-5G interference to ETC and CVO equipment supplied by Kapsch are assessed. It includes windshield, headlamp 6C and exterior mount TDM transponders made by Kapsch.

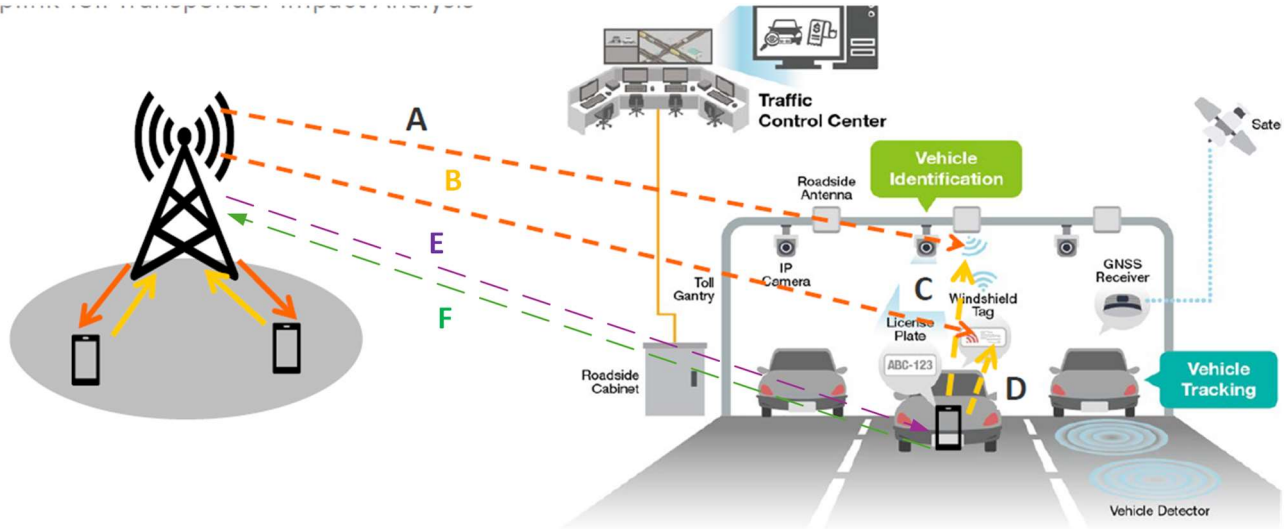
Below we have replicated the interference diagram from NextNav and added the LMS-5G links between BS and UE in vehicle to provide clarity to the path loss models for discussion. The path E represent the BS transmissions to UE's in the vehicle anywhere in the cell coverage, while the path F represents the UE transmissions to the BS. These links can be used to determine the maximum acceptable path loss (MAPL) and the corresponding cell radius of a base station.

The following interference scenarios are considered for interference potential in this study:

- LMS-5G BS to Reader (path A)
- LMS-5G BS to windshield transponder on vehicle (Path B)
- LMS-5G BS to exterior transponder on vehicle (license plate, headlamp, grille, cab roof)
- LMS-5G UE in vehicle to windshield transponder (Path D)
 - note UE's in vehicles are not expected to have much effect on external mount transponders.
- LMS-5G UE in vehicle to Reader (Path C)

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Figure 6-1: Scenario links



The items below outline how the 3GPP path loss models are applied in this study.

Paths E and F. Use PL + loss margins as per 3GPP models for computing Maximum Acceptable Path Loss (MAPL) and hence cell radius, with 90% edge of coverage probability, based on Verizon published data.

Paths A through D. Use 3GPP PL plus variables mean and standard deviation correction to determine the Minimum Required Path Loss (MRPL) for the ETC performance condition, with defined probability

- A first stage uses no standard deviation and assumes the BS or UE and AVI boresight are aligned. This identifies the links that could be at risk.
- The second state only applies if the first stage indicated possible risk to the BS and factors in BS and transponder Azimuth and standard deviations and uses this to determine the probability over all sites that the issues could occur.

Table 6-2 identifies the AVI equipment heights that are being used for path loss modelling in this study.

Table 6-2: Reader and Transponder Height Settings for Coexistence Analysis

Unit	Height (m)	Notes
Reader Antenna	5.3	Kapsch user manual [RD5] recommends 16-19 ft so mid value selected
Headlamp transponder	1.0	
Windshield transponder	1.5	
License Plate transponder	0.3	On bumper
Roof transponder	3.0	On top of transport cab

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6.1.1 Interferer Source Powers

The LMS-5G BS and UE transmission powers considered in this study are listed in Table 6-3. Because the LMS band is defined in 47CFR90 using ERP, the emissions are expressed as both ERP and EIRP in this table.

The proposed rules are unclear whether the LMS-5G emission limits are peak or average power. This uncertainty is clarified in section 4.3.1. Therefore the rules limits and also the typical emitter powers stated by NextNav are average power.

The initial high-level analysis is performed using BS-NN, and UE-NN as these represent what NextNav stated as typical, based on technology limits today. However with available current technology the levels can be a few dB higher than cited by NextNav. For example, the FCC Broadband data from AT&T cites 67.7 dBm using antennas with gain 15 dBi while section 6.2.4.1 shows there are Andrew sector antennas suitable for this application that have up to 2 dB higher gain than the value used by NextNav. Thus the typical cited by NextNav should be considered a possible average, and statistical distribution assigned based on currently available amplifiers and antenna technology, but this is not factored in the analysis by Kapsch.

Table 6-3: LMS-5G Equipment Transmit Powers

LMS-5G Emission Case	Derivation	Maximum Average Radiated Power (ERP dBm / EIRP dBm)
BS-URB-Rulemax	[RD2] Proposed urban 918-928 MHz sub-band rule of 1000W/ MHz maximum average ERP, 10 MHz BW	70 / 72.2
BS-RU-Rulemax	[RD2] Proposed rural 918-928 MHz sub-band rule of 2000W/ MHz maximum average ERP, 10 MHz BW	73 / 75.2
UE-Rulemax	[RD2] Proposed 902-907 MHz sub-band rule of 3W maximum average ERP	34.8 / 36
BS-NN	Values stated by NextNav [RD11, RD13] in technical studies for typical (urban) base stations with 40W amplifier supplying each antenna, 4 diversity antennas each 15.4 dBi gain, 1.4 dB cable loss resulting in 66 dBm EIRP. ³⁹ Note with 4-port and dual polarization there exist MIMO configurations with coherent use of 2 ports on each polarization that would result in 3 dB higher EIRP for the same power amplifiers but this was not included. Verizon had similar EIRP in their FCC National Broadband Map link budgets. AT&T cited 67.7 dBm with similar antenna gain in their National Broadband Map link budgets As well, as shown in section 6.2.4, sector antennas exist with higher gains indicating higher EIRPs than stated by NextNav are practically feasible.	63.9 / 66.0
UE-NN	As per Verizon public data	20.9 / 23

³⁹ Table B-1, [RD11], NextNav Feb 2025 study, states the 40W transmit power is (maximum) average power per antenna port, resulting in 66 dBm maximum (average) EIRP,

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6.1.2 LMS-5G Cell Sizes and Link Budgets

There are no details provided on the cell radius used by NextNav in its analyses. The only identifications of cell radius for 5G service that we found in NextNav prior submissions is a 1732 m inter-site distance for the simulations of 5G for San Francisco using the 3GPP Urban Macro model⁴⁰ though on page 51 of the same document it cites 1660 m. This seems much larger than the normal 5G deployments. Note also page 13 of the document references “appropriate elements of the evaluation methodology described in 3GPP TR 36.843, Annex A.2 (System simulation scenarios).” But the 1732 m inter-site distance in that is for a public safety scenario at 700 MHz with UE-UE communications and UE powers of 31 dBm.

More recently NextNav stated that “Neology’s assessment of the 5G PRS-based PNT network grossly miscalculates the cell radius for each environment type based on a number of critically flawed assumptions in the design of a PNT system using PRS signals, leading to the erroneous conclusion that a 5G PRS-based PNT network cannot be implemented with reasonable inter-cell distances”⁴¹ and on the next page “Using more realistic PRS configurations, ... and a corresponding cell radius of 1282 meters for the UMa channel.” which would result in greater than 1732 m inter-site distance.

Since the majority of the service to be provided is broadband wireless communications, and it is expected that the service requirements will be similar to the other sub-GHz 5G NR networks, then the cell radius is expected to be much lower than this. For the wireless communications to service consumers and also for GPS back-up to be provided by the proposed LMS-5G system, cellular data services must be available inside buildings.

As reference for cell radius consider the public link budget data from Verizon in the FCC National Broadband Map, previously cited by NextNav.⁴² The FCC provided publicly available data only provides link budgets for “Outdoor stationary” and “In-Vehicle” conditions for 5G-NR services for 1 Mbps uplink ‘Outdoor stationary’ and “In-Vehicle” conditions. The Verizon link budgets identify the technology currently in use in their system is 5G-NR, 3GPP Release 15.

The Verizon link budget data reported for the sub-GHz equivalent channel bandwidths is summarized in Table 6-4 below. The limiting link conditions are in-vehicle with MAPL of 129.6 dB at 885 MHz DL and 120.0 dB at 840 MHz UL. Applying the 3GPP Urban Macro NLOS formula we find that the d2d (cell radius) distances are 990 m and 580 m respectively. This therefore implies the 5G cell radius is only 580 m. Note that the tolerable MAPL cited by Verizon for the LTE service in the same bands is similar, as are the T-Mobile 5G budgets for sub-GHz. AT&T link budgets are 5 dB poorer for both 5G and LTE for the sub-GHz bands.

NextNav have also stated “The simulation framework introduces an indoor loss for the Urban Macro scenario ranging on an average from 20 to 32 dB, which includes indoor penetration loss of 20 dB and additional loss as a function of the simulated indoor distance of the UE up to a maximum of 12 dB. For the Rural Macro scenario, the simulation framework introduces an indoor average loss ranging from 10 to 15 dB, which includes indoor penetration loss of 10 dB and additional loss as a function of the simulated indoor distance of the UE up to a maximum of 5 dB.”⁴³

But using the Verizon link budgets with the NextNav in-building penetration numbers would imply a much smaller cell-radius. We can compute the conditions shown in Table 6-5 using the parameters defined by NextNav for BS and UE, and the 1 Mbps uplink service, resulting in minimum MAPLs of 121.1 and 112.3 dB; 7 dB less than the Verizon in-vehicle MAPLs, which introduces confusion as to the link budgets for the LMS-5G system, and the probable density of sites for the NextNav proposed system. However the positioning service needs to see multiple BS and if people are in building, the building itself will block some directions by more than 1 wall.

Kapsch believes NextNav should provide reference link budgets, both for the wireless data communications and also for the positioning service and the expected cell radius. This will avoid a lot of the confusion that has occurred between the commenters and NextNav that has resulted in some of the commentary.

⁴⁰ Page 15 and Table B-1, Page 54, [RD11], NextNav tech study. Feb 2025.

⁴¹ Page 1, [RD16], NextNav Jan 2026 Response

⁴² Page 15, [RD15], NextNav supplement to technical study, July 2025

⁴³ Page A-8, [RD1], NextNav petition.

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Since Kapsch are using 3GPP modelling for path losses, to determine the LMS-5G path losses we elected to use the maximum acceptable path loss (MAPL) to cell edge derived from the Verizon in-vehicle data for 1 Mbps uplink adjusted for the different shadow fading sigma for each of the 3GPP path models being used for LMS-5G analysis as shown in Table 6-6. Only the uplink was assessed as this is the limiting link. Note the excess DL link margin at this MAPL allows the DL spectrum to be shared to multiple UE's at the same time.

Table 6-4: Verizon 5G-NR Link Budget Summary

	DL		UL		
Frequency	885		840		MHz
Channel Bandwidth	10		5		MHz
Modulation & Coding	16QAM 1/2	16QAM 9/16	QPSK 1/6	QPSK 3/16	
Subcarrier spacing	15		15		kHz
Number of subcarriers	624		312		
TX x RX configuration	2x2		1x2		
Total TX Power	50.8		23		dBm
TX Cable loss	0.5		0		dB
TX Antenna Gain	15.5		0		dB
EIRP total	65.8		23		dBm
EIRP/subcarrier	37.85		-1.94		dBm
Target Data rate	7		1		Mbps
RX NF	8		3		dB
RX cable loss	0		0.5		dB
RX antenna gain	0		15.5		dB
	Outdoor	In vehicle	Outdoor	In vehicle	
required SINR	8.2	9.2	-3	0	dB
RX sensitivity	-116.04	-115.04	-132.24	-129.24	dBm per subcarrier
Maximum Link loss	153.89	152.89	145.30	142.30	dB
margins	9.58	23.28	8.58	22.28	dB
MAPL	144.3	129.6	136.72	120.02	dB
BASIS OF MARGINS					
cell edge probability	90%	90%	90%	90%	sigma factor 1.28
fade sigma	6.7	6.7	6.7	6.7	dB
fade margin	8.58	8.58	8.58	8.58	dB loss
head/body margin	3.0	3.0	3.0	3.0	dB loss
interference margin	3.0	3.0	2.0	2.0	dB loss
penetration margin	0	13.7	0	13.7	dB loss
other margin	0	0	0	0	dB loss
multi-cell diversity gain	2	2	2	2	dB gain
other gain	3	3	3	3	dB gain
net margin	9.58	23.28	8.58	22.28	dB loss
d2d per 3GPP UMa		990		580	m

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Table 6-5: Estimated LMS-5G In-Building Link Budget Summary

	DL		UL		
Frequency	923		904.5		MHz
EIRP/subcarrier	38.05	66 dBi EIRP	-4.94	NextNav stated UE	dBm
RX sensitivity	-113.04		-132.24		dBm per subcarrier Outdoor stationary Verizon
RX antenna and cable loss	-3	NextNav stated UE antenna	14	NextNav stated - cable and gain	dB
Maximum Link loss	151.09		141.30		dB
	outdoor		Outdoor		
Margins needed	9.58		8.58		dB outdoor Verizon
	In building min	In building max	In building min	In building max	
Total margin	29.96	41.96	28.96	40.96	dB Urban
MAPL	121.1	109.1	112.3	100.3	dB
BASIS OF MARGINS					
cell edge probability	90%	90%	90%	90%	sigma factor 1.28
fade sigma	7.0 for UMa and UMi – [RD 7.4.3.1]				dB
fade margin	8.96	8.96	8.96	8.96	dB loss
head/body margin	3.0	3.0	3.0	3.0	dB loss Verizon
interference margin	3.0	3.0	2.0	2.0	dB loss Verizon
penetration margin	20	32	20	32	dB loss per NexNav Urban
other margin	0	0	0	0	dB loss Verizon
multi-cell diversity gain	2	2	2	2	dB gain Verizon
other gain	3	3	3	3	dB gain Verizon
net margin	29.96	41.96	28.96	40.96	dB loss

Table 6-6: In Vehicle Path Model Specific MAPL

	Model	UMa	RMa	SMa	UMi	
Link Loss (max)	UE-BS (1)	143.2				dB
BS Margins NLOS	(2)	21.38	23.94	23.94	23.71	dB loss
MAPL	UE-BS	120.9	118.4	118.4	118.6	dB
d2d	LOS	2082	2386	3200	1006	m
	NLOS	582	974	584	557	m

Note (1) : As per Verizon link budget

Note (2) : As per Verizon but adjusted for 3GPP NLOS shadow fading values

6.1.3 Path Loss Models

The 3GPP [AD10] define multiple path loss models for different scenarios. For base station interference this report considers 4 model scenarios defined by the 3GPP. These models are used for assessing interference distance for both the reader and the windshield transponders. Note that the UMi model (for street canyons) is less applicable than the other path loss models for multi-lane highways but is very relevant for battery life degradation.

For the license plate transponder:

- For LOS models, the SMa-LOS is the only path model listed that has no UUT height restriction so this has been used.
- None of the 3GPP NLOS models support a <1 m UUT height which is required for cases of license plate or bumper mount of the license plate transponder, despite the fact it is the most susceptible of the TDM transponders.
- Non withstanding both LOS and NLOS versions of the SMa model are analyzed.

For the UE in the vehicle we can consider 3 cases of the UE:

- The UE is used by driver or front passenger or located so it is visible to the driver or passenger (e.g. on dashboard). For this case, both the transponder in the vehicle and the reader antenna best suited to the transponder read can be considered to be in clear line of sight from the UE.
 - There can be significant multipath from the vehicle, so a Free-space model (FSPL) may not be appropriate, but has been included for completeness.
 - The only potentially applicable 3GPP path model for UE interference modelling for this case is the INH-LOS model, to address the multi-path reflections within and from the vehicle..
- The UE is used by other passengers in the vehicle, or below the dashboard, e.g. when using Apple CarPlay and the cell is linked to the vehicle display via Bluetooth. In this case the transponder or reader is not in direct line of sight of the UE.
 - The only potentially applicable 3GPP path model for UE interference modelling for this case is the INH-LOS model.
- The UE is in another vehicle, but its signal can reach the transponder in the vehicle under consideration or the reader in another lane. For the interference to the transponder it may be applicable to use the 3GPP or ITU car penetration loss models + FSPL. For the interference to the reader the reader antenna azimuth patterns will reduce the interference at the reader.
 - This UE case is not addressed in the risk evaluations in this report.

In the normal link budget the MAPL is defined as

$EIRP - MAPL - Margins = \text{required RX sensitivity for communications at cell-edge with 90\% probability.}$

In the modelling of path loss for interference we are looking for the solution to :

$$EIRP - PL - N(AvC, \sigma_C) - N(0, \sigma_S) < Sus(PER)$$

$$EIRP - (Sus(PER) + AvC) < PL - N(0, \sigma_C^2) - N(0, \sigma_S^2)$$

$$EIRP - (Sus(PER) + AvC) < PLS \quad [EQ \ 1]$$

$$PLS = PL - N(0, \sigma_C^2) - N(0, \sigma_S^2) \quad [EQ \ 2]$$

$$MRPL = EIRP - (Sus(PER) + AvC) \quad [EQ \ 3]$$

$N(AvC, \sigma^2)$ represents the statistical variables except shadow fading expressed as a normal distribution in dB with a mean of AvC and a standard deviation of σ_C and is discussed in section 6.2.

$N(0, \sigma_S^2)$ represents the shadow fading distribution, specified by 3GPP.

$Sus(PER)$ represent the device susceptibility for a particular packet error rate. See Section 6.2.1.

6.2 Parameters with Variance Used In The Link Modelling

First we analyze assuming the BS antenna sector is directed at the AVI site and the AVI equipment pointed towards the BS.

- Like NextNav we use the “typical” BS EIRP and the BS antenna model identified by NextNav, but we model the elevation pattern using ITU F.1336-5 methods. See section 6.2.4.
- Like NextNav we use 100% traffic on the LMS-5G links to assess this high level risk. Note if risk is identified, then the effect of traffic distribution will be a factor in the probability of missed transactions at the site, but this is not discussed herein.
- The remaining variables in the RF link are discussed and treated with the appropriate model and the average AvC and standard deviations assigned.
- For the first stage we only use the average of the statistical parameters, and zero azimuth of the antenna patterns to obtain the interference potential over a range of ground distance.
- If there is no interference potential then there is essentially no coexistence risk as this solved loss vs radius represents an upper bound on the interference.

UE orientation effects on polarization loss are discussed in section 6.2.3.

There is variability in the individual transponder model free-space characteristics, so the average transponder susceptibility levels were selected from the test data for coexistence and are reported in Table 6-13. Given the small population measured the p-p deviation computed over the measured data can only be used to estimate a standard deviation. Further there are production variations, life and temperature in the transponders which are not accounted for in the measurement. These are discussed in Section 6.2.7.

The variation of signal strength over the capture zone is discussed in section 6.2.1. The PER condition used for coexistence analysis is also discussed in that section.

For assessing base station interference, we consider the EIRP is fixed at maximum power of a typical base station, as was used by NextNav.

The 3GPP path models identify many statistical variables contributing into the link budget and the link budget for wireless service is established based on probability of achieving service. For example the Verizon link budgets include margins for particular categories, such as penetration loss and fading. Note the 3GPP PL equations in [AD10] TR 38.901 table 7.4.1-1 are for the mean path loss (PL) prior to considering those margins. These are discussed in Table 6-7. Note Verizon used $1.28 \cdot \sigma$ for shadow fading to obtain 90% probability of edge of cell coverage.

Vehicle penetration loss is discussed in in section 6.2.2.

The 3GPP path modelling document states for shadow fading “*The long-term (log-normal) fading in the logarithmic scale around the mean path loss PL (dB) is characterized by a Gaussian distribution with zero mean and standard deviation. Due to the shadow fading process versus distance Δx (Δx is in the horizontal plane), adjacent fading values are correlated*”. The shadow fading correlation distance in the horizontal plane is much larger⁴⁴ than the width over multiple lanes at a toll site, and except perhaps for UMi much larger than the entire toll site so the shadow fading can be considered correlated over all lanes of a toll site, negating any consideration of diversity benefits from the adjacent lane antennas, and implying multiple ETC devices will be affected at the same time.

The combined results for average and standard deviation are listed in Table 6-9.

The impact of antenna azimuth patterns is later discussed in Section 6.5.

⁴⁴ Table 7.5-6 in [AD10] 3GPP path loss models

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Table 6-7: Applicability Of Other Margins

Item	Wireless Communications Link Budget	Path to AVI device Link Budget
Head/Body Margin	Reflects UE is carried by person	Not applicable
Shadow Fading	1.28*sigma for 90%	Include but as mean and sigma
Interference Loss	From adjacent cells due to cell loading	First stage - not applicable Next stage – include adjacent sector
Penetration Loss Margin	As per UE location	0 dB see Section 6.2.2
Other margins	Not defined but value 0 dB	0 dB
Multi-Cell diversity gain	Multi-cell switching or macro-diversity gain	Not applicable
Other gains	Not defined but assumed to be related to 5G processing	Not applicable
Reader cable loss	Value assigned in Link budget	Assumed 1 dB in reader antenna gain

Table 6-8: Summary Of Mean And Standard Deviations For Variables With Standard Deviations To Be Combined

Item	Average change (dB) (1)	Standard Deviation (dB)	Section
ETC device variability	0 – accounted for in Table 5-1	See section 6.2.7	
UE penetration to reader	- 3	0	6.2.2
Penetration other	0	0	6.2.2
Shadow fading	0	As per 3GPP	
PER	5% at wake-up	0	6.2.1
Polarization	-3 BS -6 UE	0 BS 3 UE	6.2.3
BS azimuth (2)	Az=0 for first stage Average over +/- 60% Az at each radius + adjacent sector power	Probability of gain values over the Az range at each radius	6.5
ETC azimuth	Az=0 for first stage Note: For the BS-reader case the elevation down-tilt already resulted in the off-axis limit for analysis.	Gain probability distribution over azimuth angle included in second stage analysis	6.5

Note (1): They are expressed as -ve margins since they represent reduction of the interference at ETC device.

Note (2): BS azimuth is only addressed in second order stage of coexistence analysis.

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Table 6-9: Effective Margin (excl Shadow fading) for MRPL

Protocol	Path	Net Average (dB)	Net Standard deviation (dB)
TDM	BS- Reader	-3	1.0
	BS-Transponder	-3	0.9
	UE-Reader	-6	3.2
	UE-Transponder	-6	3.1
TDMA	all	As TDM	
6C or SeGo	BS- Reader	-3	3.0
	BS-Transponder	-3	2.5
	UE-Reader	-6	4.2
	UE-Transponder	-6	3.9

Note : Negative average margins mean they result in reduction of the interference at the ETC device, see equations above.

6.2.1 Capture Zone Variation and PER Condition for Analysis

Multipath, vehicle variability and fast fading effects apply when considering the signal levels at the ETC device through the toll capture zone.

The capture zone link loss varies not only with the distance from the reader but also the azimuth and elevation effects of the reader and transponder and the position of the transponder relative to the reader antenna.

Section 4.2.1 provides some examples of the effect of 2 different vehicles and transponder models along the 0 azimuth path through the capture zone. The data for one transponder is repeated in Figure 6-2.

There are many other factors that apply including but not limited to multipath from other vehicles, location across the road relative to the 0 azimuth path, relative timing between reader use of the protocol and transponder position in the zone, and relative levels of adjacent antenna power. Unfortunately there is no statistical model for this link loss distribution over the capture zone and vehicles.

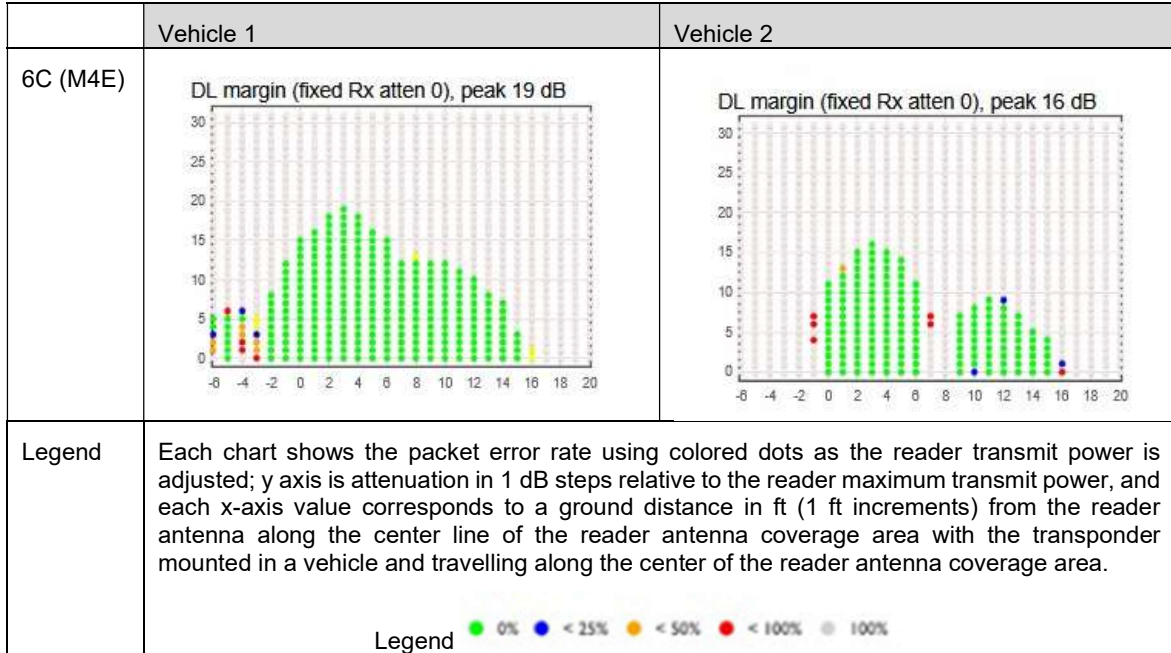
Note also the TDM transponders susceptibility is not dependent on I/S but purely on I/Wake-up level therefore variation in ETC signal level over the capture zone has no meaning for TDM susceptibility.

The ETC system downlink is tuned to obtain a nominal capture zone but also to ensure that vehicles such as Vehicle 2 (above) are captured by the system. While E-ZPass ETC system requirements are >99.95% for transponder capture, there exist toll systems that require higher performance. The allowance for LMS-5G interference would need to be <0.01% capture failure rate for E-ZPass and even less for the higher performance systems.

NextNav analysis indicated that with their modelling the 5% PER at wake-up levels were never exceeded, and the 5% PER at wake-up was also the criteria used by Neology, therefore for consistency, the analyses for coexistence herein use this as the criteria for coexistence risk assessment.

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Figure 6-2: Example of Downlink Margins in Antenna Coverage Area



6.2.2 Vehicle Penetration Loss

Comments [RD8, RD10] have been directed to the NextNav use of 5 dB vehicle penetration loss where NextNav stated [RD7] for the 5G downlink analysis “*Transponder settings ... 5 dB vehicle penetration loss was applied instead of ITU recommended 9 dB to account for typical transponder mounting on windshields*”, i.e. the modelled path losses computed for interference levels at transponders included 5 dB extra path loss for this factor.

In their recent response NextNav attempts to justify the 5 dB stating “*Neology’s claim that vehicle penetration loss in NextNav’s downlink propagation coexistence study should be less than 5 dB ignores the standard in-vehicle loss models used by the wireless industry. NextNav’s 5 dB in-vehicle average loss assumption is actually a conservative assumption; 3GPP models often suggest higher average losses over the random incidence angles of the arrival signal and the glass materials, which depend on the location of the 5G base station relative to the car. In recent proceedings, the Commission has consistently applied penetration losses to prevent “worst-case” assumptions from dictating spectrum policy.*”⁴⁵

However the wireless industry uses vehicle penetration loss for communications to devices **within** the vehicle. The standard wireless communication models cover the full 360 degree azimuth range around the vehicles and a range of UE placements within the vehicles and the mean and standard deviation in the penetration models cover this entire range of variables.

Windshield transponders are mounted to the windshield glass and free space performance data is measured including the effects of window glass. Thus windshield transponder can effectively considered to be a transponder on the exterior surface of the windshield. This applies for even metalized windshields, as the windshields have RF windows at transponder mounting locations. Further there are exterior mount transponders.

Within the +/- 90 degree of transponder azimuth boresight there is no vehicle penetration loss applicable for the transponder. Thus the 3GPP models are not applicable as they have normal distribution statistics. Instead of applying a mean penetration loss, NextNav could have considered the road geometry and assigned the appropriate

⁴⁵ Page 12, [RD16], NextNav response Jan15, 2026

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penetration loss for azimuth angle between road direction and BS. NextNav claim to have considered the geometry to the reader antennas so it should have been easy to apply the same approach to the transponders.

Because the penetration loss is 0 dB for 50% of the 360 degree range for transponders, and highway ETC sites cover both directions of highway normally, a net value of 0 dB penetration loss is appropriate, noting that 50% of all transponders at that site will be affected. This 50% factor should not be applied to the link loss, but to the probability of occurrence.

NextNav made no statement about the use of vehicle penetration loss it used in determining the Complementary Cumulative Distribution Function (CCDF) for UE emission levels at readers and transponders that it provided in its report. Since 3GPP path loss models are being used, then surely the 3GPP vehicle penetration models [AD10 7.4.3.2] should be used in determining the UE emission power levels. The 3GPP specifically define the additive car penetration loss to be $N(\mu, \sigma_p^2)$, a normal distribution in dB, with $\sigma_p = 5$ and $\mu = 9$ for non-metallized windshield vehicles, $\mu = 20$ for metalized windshield vehicles.

It is noted the Verizon link budget included a 13.7 dB margin for vehicle penetration loss for BS-UE links. It is not clear if this is intended as a blend of non-metalized and metalized cases or some other statistical approach is used.

Since thermal film (metalized) windshields and front side windows are becoming more prevalent in vehicles, the CCDF for UE emissions should be computed taking this into account, and how it is accounted for. It would be significantly detrimental to ETC system performance if metalized windshield vehicles were significantly affected, since these perform properly in the current ETC systems due to the RF windows at transponder locations.

For UE – reader susceptibility, the “penetration loss” for the UE to reader will be much less than the 3GPP models since the reader antenna is in front of the vehicle. For our modelling we will assume 3 dB with 0 dB standard deviation.

Note that the BS serving the UE when looking at UE-Reader interference is not the same BS that would be the primary interferer to the reader since the reader boresight is facing in the opposite direction to the vehicle direction of travel. Similarly the BS serving the UE may not be the BS interfering with the transponder or with the reader.

6.2.3 Polarization

NextNav state that polarization losses were not included⁴⁶. Modern wireless communications including 5G use dual polarization for BS transmit and BS receive, while UE transmit currently uses single or dual polarization in the sub-GHz bands. The UE receive is assumed to use dual polarization on receive, in order to properly receive the BS transmissions.

- The Verizon link budget data in the FCC National Broadband Map defines the UE as 1x2 (1 transmit, 2 receive) with transmit power 23 dBm and 0 dBi antenna gain, i.e. single polarization TX
- The AT&T link budget defines the UE as 2x2 (2 transmit, 2 receive) with transmit power 23 dBm and -3 dBi antenna gain plus 1 dB feed loss, it is not clear but it is possible this is dual polarization TX.
- The T-Mobile link budget (at 678 MHz) defines the UE as 1x4 (1 transmit, 4 receive) with transmit power 22 dBm and -5 dBi antenna gain, i.e. single polarization TX.

The following therefore has been used for polarization loss in the analysis:

- BS to ETC – 3 dB loss
- UE to ETC – depends on whether 1x2 or 2x2:
 - for 1x2 the polarization in relationship to the ETC device depends on UE placement by the user. The rotation of the device could result in anywhere from 0 dB to full x-pol isolation, but also multipath in vehicle can have a significant impact on the gain to the ETC polarization.
 - The 2x2 with dual polarization would only have 3 dB polarization loss to the ETC device

⁴⁶ Pages 23, 30, 31 [RD7] NextNav Tolling Coexistence Study and in [RD16] NextNav Response Jan15, 2026

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- For this study the 1x2 UE was assumed. The variability was modelled by setting a polarization loss average of 6 dB with a standard deviation of 3 dB.

6.2.4 Antenna Patterns

6.2.4.1 BS Antenna

NextNav cited a particular sector antenna in their Jan15 submission⁴⁷ which has at the 902-928 MHz band a 60 degree azimuth beamwidth, a 7.6 degree elevation beamwidth, and their tolling coexistence study used the same antenna parameters which they modelled with 4 degree down-tilt in all locations⁴⁸. NextNav themselves admitted that for 3-sector antennas the elevation beamwidth can be up to 10 degrees. In fact Andrews have multiband sector antennas that go up to 13 degrees elevation beamwidth⁴⁹. It is also noted that the antenna identified by NextNav for their experimental system tests in California has much broader elevation beamwidth (23 degrees)⁵⁰.

Since it is possible that the addition of the LMS-5G service to existing wireless providers will use the existing antennas, it is not reasonable to assume a fixed antenna characteristic, unless the intention is independent deployment of BS antennas for this band, or replacement of existing antennas with this specific antenna. Therefore other elevation geometries and antennas need to be considered, especially when considering battery life degradation due to passage and parking of vehicles in closer proximity to a base station.

Figure 6-4 shows the difference in antenna gain for 5 Andrews antennas versus distance from base station created using the ITU F.1336-5 model. Note the down-tilt was adjusted in each case to keep the interference down into the overlapping cells, as would be necessary for the wireless system. Also note that three of them have 1 to 2 dB higher gain than the model selected by NextNav for simulation, hence the EIRP from the BS could readily be increased by this amount compared to the NextNav identified typical. This also indicates that for the most part, the BS antenna main lobe applies at ground distances above 100 m.

NextNav also stated *"By contrast, 5G signal levels are reduced by approximately 26 dB at 50 meters separation and approximately 15 dB at 100 meters separation with realistic antenna discrimination"*⁵¹ and cited the same antenna used in their studies. However for general assessment, the ITU F.1336-5 elevation sidelobe gain patterns show much less than the NextNav stated suppression at those distances

NextNav later provided an example⁵² showing one of the Andrews antennas versus the ITU pattern which is reproduced below in Figure 6-3, where the peak sidelobes exceed the ITU peak sidelobe model significantly. Note that the +ve elevation angles in the figure indicate angles below the horizon. This antenna would only have ~12 dB suppression to a reader at 50 m ground distance at 25 m BS height. Note this antenna could be suitable for operators who wish to add the new LMS-5G to their system without having to change the existing antennas. The NextNav figure title is also slightly misleading since it is titled "Vertical Antenna Patterns" but the antenna referenced has dual slant +/-45 degree polarization.

Also note that ITU F.1336-5 clearly states *"at large angular distances from the main beam pattern gain may not fully represent the antenna emissions because of local ground reflections"*, which could result in even less suppression at these distances.

⁴⁷ Footnote 20, Page 5 [RD16] NextNav Response Jan15, 2026

⁴⁸ Page 20, [RD7], NextNav Tolling Coexistence Study

⁴⁹ See Andrew RRVV-65A-R4VB01: 8-port sector antenna, 4x 698–960 and 4x 1710–2690 MHz 'https://www.andrew.com/products/base-station-antennas/antennas/itemrrvv-65a-r4vb01/

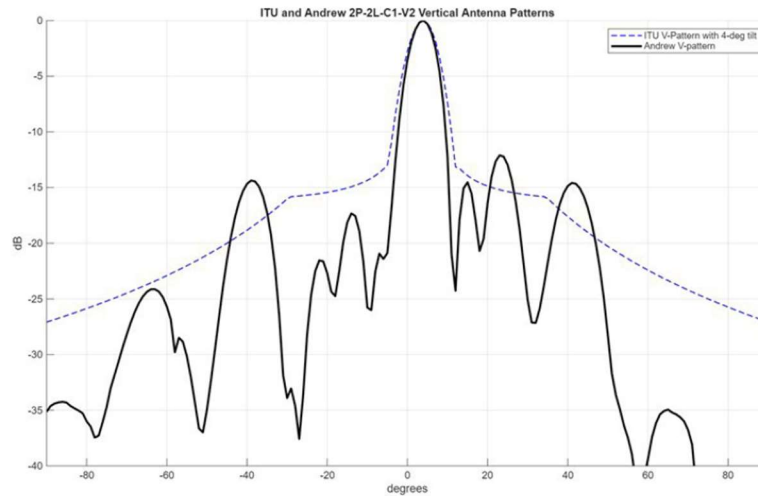
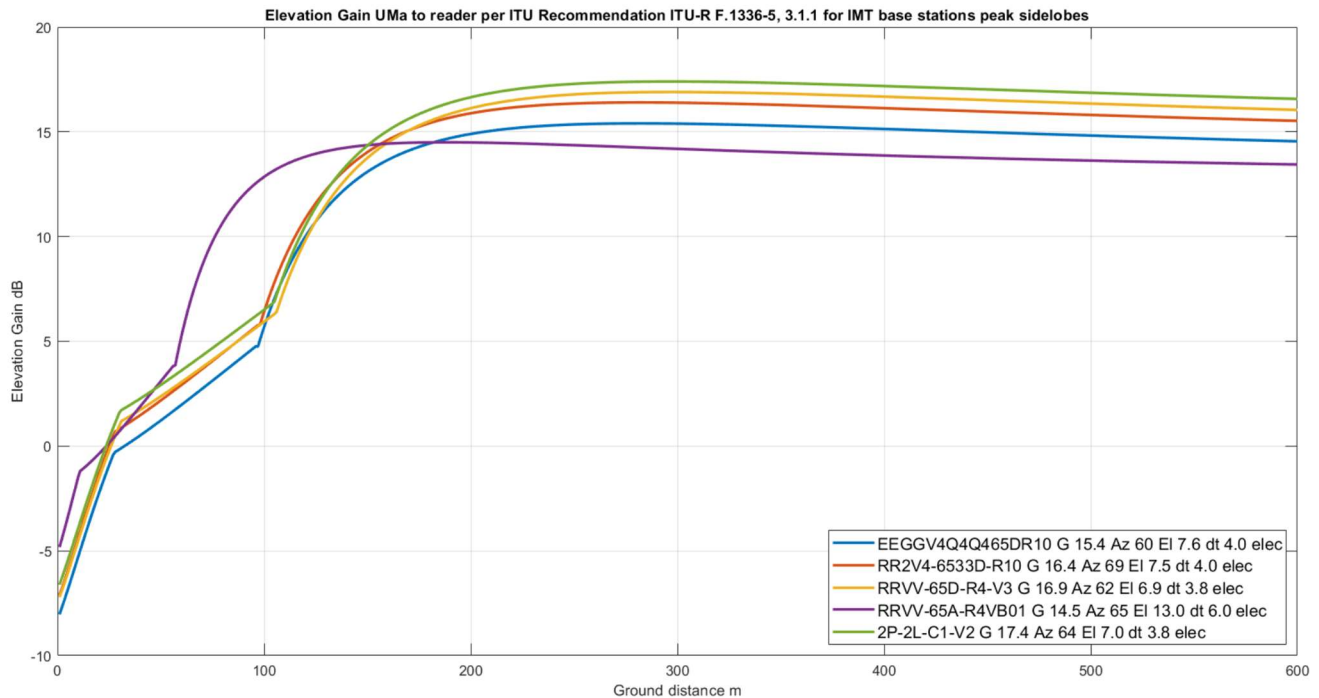
⁵⁰ Antenna Data Sheet, Cambium Networks 900 MHz 60 degree Azimuth sector antenna for 8 Site NextNav San Jose Experimental Test, Callsign WP2XYS, as filed with FCC OET under file 0622-EX-CN-2025 6-17-2025 and referenced on page 1 of the technical details exhibit.

⁵¹ Footnote 20, Page 5 [RD16] NextNav Response Jan15, 2026

⁵² Figure 9, Page 19, [RD18] NextNav response to SIA, Jan 2026

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For these reasons use of the actual antenna pattern of a specific BS antenna is not necessarily representative and instead the ITU-R F.1336-5 peak sidelobe model for a sector antenna is used by Kapsch to identify if co-existence issues can exist.

Figure 6-3: Antenna comparison to ITU from NextNav*Figure 9. Elevation antenna pattern comparison between ITU⁶⁶ and actual base station antennas***Figure 6-4: Base Station Antenna Elevation Gain vs Distance**

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6.2.4.2 UE Antenna

For the UE, NextNav used omni pattern and -3 dBi antenna in their analysis.⁵³ However NextNav cited the Verizon public data in their February 2025 study⁵⁴ and Verizon specified 23 dBm transmit power and 0 dBi for UE link budgets.

The analysis herein is based on UEs using 23 dBm transmit power and 0 dBi antenna but accounting for polarization loss (see section 6.2.3).

6.2.4.3 Reader Antenna

NextNav used a free-space reader antenna pattern in their tolling coexistence simulations – they stated that they used the “14 dBi toll reader antenna (above) with orientation toward the incoming traffic with 75° down-tilt”⁵⁵ and presented a (free-space) antenna pattern purported to be that of a Kapsch antenna. However this is not the actual pattern of a Kapsch antenna and the model used to generate this should be identified. Further different toll vendors and integrators can use different antennas, so use of a specific pattern is not fully representative.

NextNav stated “Industry standard RF planning tool (InfoVista Planet) was used to design typical 900 MHz 5G deployments and predict 5G downlink signal levels at actual toll locations in several markets, including Northern Virginia”⁵⁶ and “5G signal strengths at identified toll reader heights were calculated using Planet propagation prediction tool, accounting for reader antenna gain in the direction of the 5G transmitters”.

However the reader antenna pattern shown by NextNav in that study has >30 dB suppression above 75 degrees from boresight. While reader antennas have good sidelobe patterns in free space, 30+dB sidelobe rejections at and above the horizon are not achieved in practice.

- There is usually high reflectivity from road surfaces so effective elevation suppression to a BS is substantially reduced.
- There is high reflectivity from vehicles so both elevation and azimuth suppression to a BS is substantially reduced, and significant multipath effects created.
- There are other sources of reflection that contribute also.
- There is no simple model for these reflection effects.

Because of the high down-tilt value and high elevation beamwidth the ITU F.1336-5 model for a sector antenna cannot be used to represent a reader antenna. Instead Kapsch used measured data on a Kapsch IAG3 antenna but limited the off-axis suppression to -30 dB below boresight to cover the above issues.

Note that since the first stage modelling elevation angles from Reader boresight to BS are >75 degrees, and already at the off-axis limiting level the azimuth pattern of the reader is not applicable in second stage analysis of BS interference.

The Kapsch IAG3 antenna has a boresight gain of 14 dBi, an elevation beamwidth of 40 degrees and an azimuth beamwidth of 29 degrees. Kapsch assumed a deployment with a cable loss of 1 dB and the typical setting of 75 degree down-tilt.

Note that for CVO the reader antennas are pointed at low elevation down-tilt so the antenna gain in the BS direction will be much higher. No analysis is performed with respect to CVO reader susceptibility in this report, but could be a subject of a later comment submission.

⁵³ Appendix, [RD7] NexNav NextNav Tolling Coexistence Study states 20 dBm maximum EIRP based on 23 dBm transmitter power with -3 dB antenna gain.

⁵⁴ FCC, National Broadband Map: Data Download, data by provider,(Verizon) latest version (January 2026), Supporting Data, Mobile Broadband, 5G-NR

⁵⁵ Page 30, [RD7] NextNav Tolling Coexistence Study

⁵⁶ Page 19, [RD15], NextNav Tolling Coexistence Study, Aug 2025.

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6.2.4.4 Transponder Antennas

NextNav used omni directional gain for the transponder pattern in their susceptibility analysis, which is correct for a high level assessment. Transponder free space antenna patterns were discussed in Section 4.4 and generally have dipole characteristics.

The dipole characteristic does not include vehicle blocking and penetration effects in the rear direction. For a more detailed coexistence analysis, such as the second stage analysis in section 6.5, reasonable approximations for interference analysis for a transponder on a vehicle are:

- For windshield transponder susceptibility to BS, the transponder antenna pattern can be considered to have only the forward facing azimuth lobe and be uniform in elevation gain from 0 to 90 degrees elevation above the road.
 - This also applies for license plate and headlamp transponders.
 - The off-axis azimuth rejection should be limited rather than ideal to encompass multipath and other effects.
- Note that due to fact many tolling sites have coverage for both vehicle directions this means 50 percent of the azimuth range at a toll site will have <3 dB pattern loss for BS interference to transponders due to transponder antenna patterns.
- There is generally an increase of 1-2 dB in gain of transponders on vehicle vs free-space but this is not included in the analyses herein.
- We approximate for analysis purposes that there is no antenna gain existing outside azimuth +/- 90 degrees, because in many angles the transponder does not have line of sight in the rear direction towards the BS and vehicle penetration losses also apply.
- The azimuth pattern can be modelled using $G=\sin^2(\theta)$ but limited in off axis suppression to account for multipath and shadowing effects.
- Roof mount transponders have essentially the azimuth dipole antenna pattern and an elevation pattern with boresight pointed vertically above the vehicle roof, caused by the metallic roof, and no response below the vehicle roof. The transponder boresight gain is typically 3 dB higher, due to the effect of the metal roof on which the transponder is mounted, but the gain rolls off with elevation. A reasonable assumption is net -10 dB relative to free-space boresight in direction of BS at any realistic transponder - BS separation. Thus we can ignore roof mount transponders for this coexistence susceptibility analysis.
- For transponder susceptibility to UEs, with respect to UEs in the same vehicle, there is effectively no pattern loss due to transponder-UE angle in either axis.

6.2.5 LOS Probability

The 3GPP models for LOS probability cover all locations in the view of the base station, but for the most part ETC sites are located on main roads and have much clearer visibility to base stations than the average consumer UE conditions. Also it has been observed in practice that the base station cell tower antennas can be seen visually from some toll sites, where the distances are larger than those the 3GPP models will predict. Therefore the 3GPP models for LOS probability cannot be used to predict the transition between LOS and NLOS models for multi-lane ETC sites.

A particular concern of the ETC community is the presence of a BS down the highway (but off to the side) in either direction of travel, since the toll sites can be tolling in both directions. Roads do curve, so the net effect may be zero offset to the side in some cases. Further as shown later in the results the critical coexistence issues are in the ground distance range 100-300 m from the AVI site for multi-lane highways and thus the azimuth angle from the AVI site is small, reinforcing the validity of using no azimuth reduction in the first stage analysis.

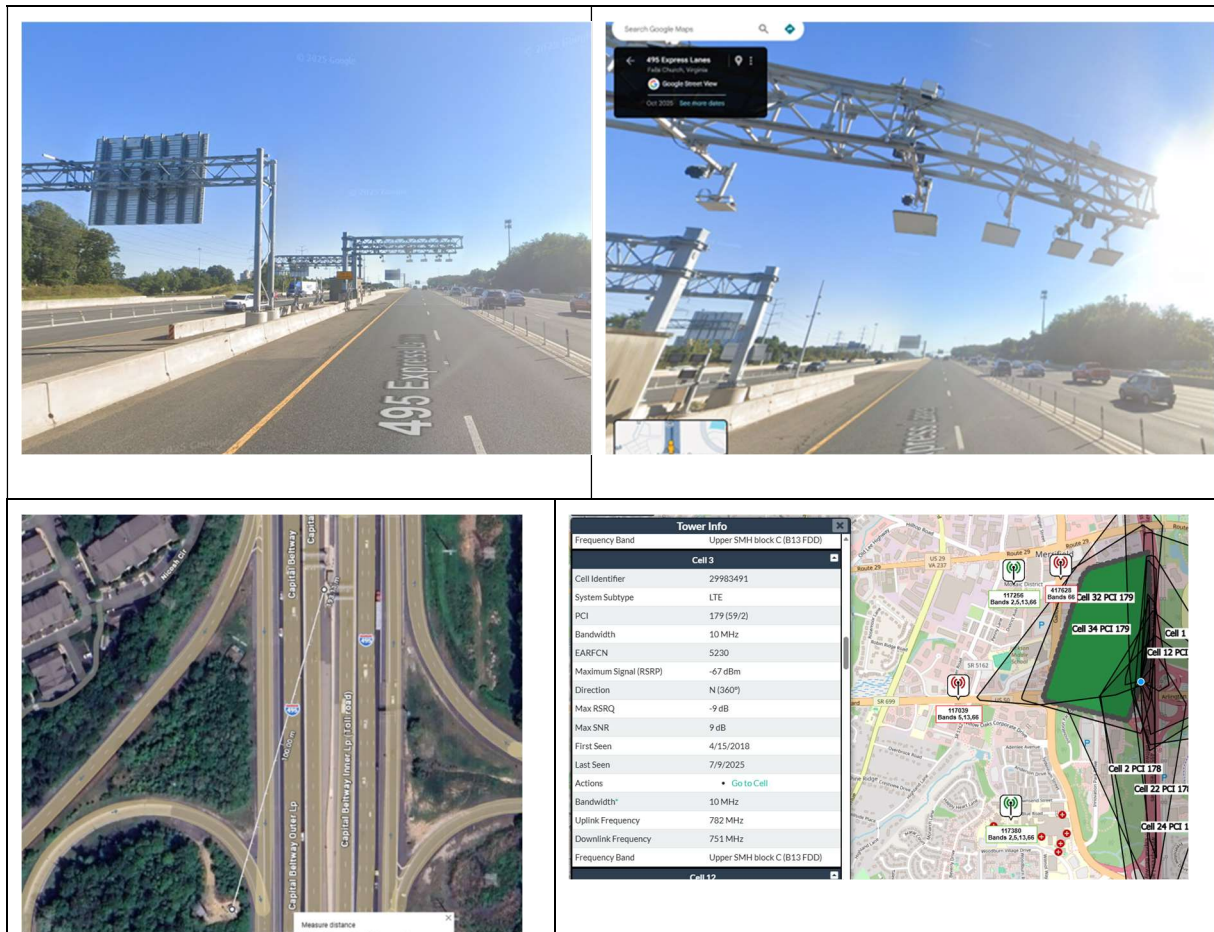
Wireless providers currently show link budgets for both LTE and 5G in the FCC National Broadband Map, and the wireless providers may elect to add the LMS-5G to their existing cell towers. An example site is shown in the figure below (courtesy Google Maps, <https://cellmapper.net/> <https://www.signalboosters.com/blog/find-your-nearest-cell-tower-quickly-and-painlessly/>) that shows ETC equipment covering both directions and LOS to an LTE tower 193 m

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away. Currently there is no sub-GHz 5G on this tower but there is no reason LMS-5G could not be added to this tower.

Also it can be seen that the LOS distance can be much larger than the 193 m measured for this example when the base station is next to the road, confirming the rationale not to include the 3GPP LOS probability for ETC site interference. This long LOS visibility is also important when considering the effects on battery life which are not restricted to the AVI sites.

Figure 6-5: Example BS LOS to AVI on Highway



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6.2.6 Activity/Loading Factors and ETC Traffic Profiles

NextNav stated they used 20% loading factor on the base stations in their coexistence analysis and included this in the RSSI in the downlink analysis⁵⁷. This value of 20% is the subject of dispute⁵⁸ but in addition Kapsch believes using the loading factor to adjust the RSSI, i.e. effectively increasing the link loss, is not a valid approach for this type of analysis. The base station loading should only be used to evaluate the probability that interference is present, not to determine distances at which interference can affect the toll equipment.

Similarly NextNav stated they used 0.045% activity factor for the UE in their coexistence analysis⁵⁹, and they determined the CCDF of the UE signal levels at the toll equipment factoring the activity into the distribution of RSSI. Again the value of 0.045% is the subject of dispute⁶⁰ and further Kapsch believes using this to adjust the RSSI is also incorrect.

Kapsch also notes that BS loading and UE activity factors should be considered from a statistical perspective taking into account the vehicle traffic statistics at toll sites. Vehicle traffic at toll sites is not uniform over time; there are periods in the day at any toll site where it peaks and interference at these times will have a higher impact on missed transactions than at other times of day. If base station loading or UE activity is to be considered, then a proper statistical analysis would compare the temporal distributions of vehicle traffic statistics at toll sites and those of base station loading and user traffic in the wireless broadband system and derive a statistical distribution so that the percentage of toll traffic impacted by base station activity is properly modelled.

Kapsch has elected not to include BS loading and UE activity in its modelling, as these are in dispute.

6.2.7 Product Variation

The equipment testing reported in section 5 is non-exhaustive and only covers ambient temperature conditions. There is variance in product which adds statistical variation to the measured transponder wake-up/EIRP values. We also measured variation in the susceptibility of the different transponders. The table below indicates the values that were assigned for analysis. Note many are estimates for the purpose of analysis.

Table 6-10: Product Variance Statistics

dB variability	manufacturing	Range of susceptibility measured p-p See Table 5-1	Life and temperature	Standard deviation assigned dB
TDM wake-up (boresight)	+/- 1	2.5	+/- 1	0.9
TDM EIRP	+/- 1.5	1.0	+1 / -6 (1)	1.0
TDM variance of reader	Not known	Not known	+/- 1 est	1.0
6C wake-up (boresight)	+/- 1.5 est	9.4	Not known	2.5
6C backscatter (EIRP)	+/- 2.0 est	10.9	Not known	3.0
6C variance of reader	Not known	Not known	+/- 1 est	1.0
TDMA	Assume same as TDM			
SeGo at Reader	Assume same as 6C			

⁵⁷ "20% average 5G downlink loading was assumed, and RSSI reflects the loading in the analysis", Page 29, [RD7], NextNav Tolling Coexistence Study.

⁵⁸ E.g. Page 10, [RD16], NextNav Jan 15 2026 Response.

⁵⁹ "Each simulated iteration calculated the 5G signal strengths (RSSI) at the toll transponder and the toll reader from the 5G UE accounting for both UE power control and activity factor", Page 32, [RD7], NextNav Tolling Coexistence Study.

⁶⁰ E.g. Page 11, [RD16], NextNav Jan 15 2026 Response.

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Note(1) : Towards the end of life the transponder EIRP will drop. This is not included in the statistical modeling but can be assessed by looking at the margin if any between the reader MRPL and the minimum PL in the cell radius.

6.2.8 Differences for Battery Life Impact Assessment

For the battery life impact assessment the AVI capture zone does not apply. What matters is the time per BS or UE that exceeds the current threshold of susceptibility identified in Table 5-1 plus the variance. The problem in assessing life degradation is in modelling the probability that the vehicle carrying the transponder is within that susceptibility range, variable over all BS, and how often it is in the susceptible range per day.

Ideally the current threshold should never be exceeded.

In the event it is exceeded the model for assessment is discussed in section 6.5.

6.3 Path Model Settings

Figure 6-6 shows the reference planes for the measurements summarized in Section 5. For the transponder data the results in Table 5-1 can be used directly with the source power levels in Table 6-3 to obtain the path loss, however for reader sensitivity the cable loss and reader antenna gain need to be considered.

Figure 6-6: Measured Susceptibility Reference Planes

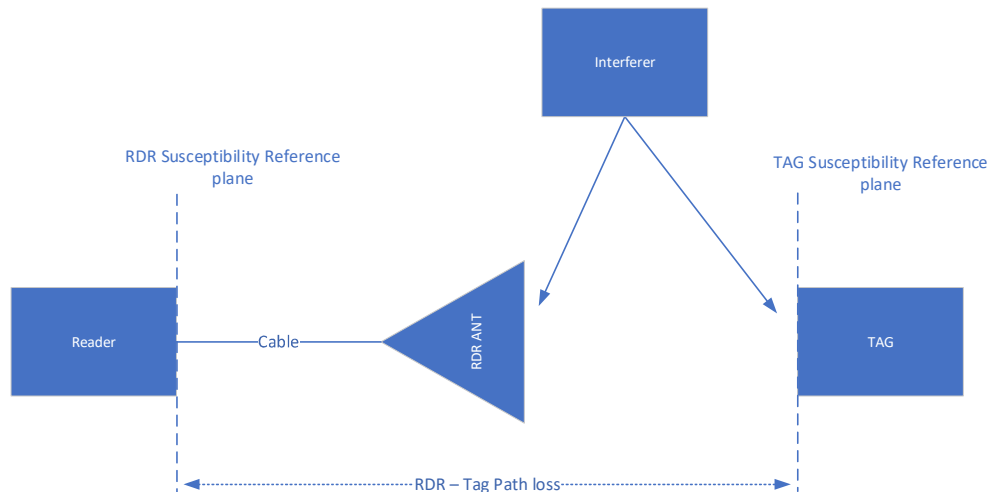


Table 6-11 lists the AVI device heights that were used in the 3GPP modelling.

Table 6-11: Reader and Transponder Height Settings for Coexistence Analysis

Unit	Height (m)	Notes
Reader Antenna	5.3	Kapsch user manual [RD5] recommends 16-19 ft so mid value selected
Headlamp transponder	1.0	
Windshield transponder	1.5	
License Plate transponder	0.3	On bumper
Roof transponder	3.0	On top of transport cab

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Table 6-12 lists the parameters that were used for evaluating the path loss PL for the interference links.

Table 6-12: Path Loss Model Settings for Analyzing AVI Susceptibility Distances to LMS-5G Signals

Path	BS to AVI device				UE to AVI device	
3GPP Path model	UMa	RMa	SMA	UMi	INH	FSPL
Interference source height (m)	25	35	25	10	1.2	1.2
Environment height m	1					
Building height m	n/a	5	10	n/a	n/a	n/a
Minimum source height (m) for model validity (1)	Fixed at 25	10	25	Fixed at 10	n/a	n/a
Minimum UUT height (m) for model validity (1)	1.5	1	1	1.5	n/a	n/a
Minimum ground distance (m) for model validity (1)	10	35	10	10	1 (3D path length)	n/a
Maximum distance (m) for model validity (1)	5,000	10,000	5,000	5,000	150	n/a
AVI susceptibility levels	Use 5% PER values at wake-up					
Penetration loss to AVI device	0 dB				0 dB transponder 3 dB reader	
Shadow fading application to AVI	0 dB to ETC 1.28 Sigma for BS-UE link				Not applicable	
Shadow fade sigma LOS (dB)	4	4	6	4	n/a	n/a
Shadow fade sigma NLOS (dB)	6	8	8	7.82		
Polarization loss to AVI	3 dB				6 dB mean	
BS Antenna Gain	Per ITU F.1336-5 for IMT sector antenna peak sidelobe AZ BW= 60 deg, EL BW= 7.6 deg, down-tilt 4 deg				0 dBi	
UUT Antenna gain towards LMS-5G	Reader antenna 14 dBi gain , AZ beamwidth 29 deg, EL BW= 40 deg, down-tilt 75 deg. , sidelobe suppression limited to -30 dB 1 dB cable loss					
	0 dBi transponder, Omni Elevation Az using $G=\sin^2(\theta)$ over +/-90 degrees					

Note (1): based on formula restrictions in [AD10], Table 7.4.1-1.

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Figure 6-7 shows the PL for example without the BS antenna patterns being factored in for the 4 3GPP Path Models.

Table 6-13 lists the AVI device susceptibility values, extracted from Table 5-1 and Table 5-2, and compared with the NextNav reported data. Note the SeGo transponder is not included as it is not a Kapsch device.

Table 6-14 shows the MAPL for each 3GPP model, derived from the limiting case of the Verizon link budget.

Table 6-13: Kapsch Product Susceptibility Levels for Minimum PL Analysis

Equipment	Protocol and LMS-5G Link Direction	Interference Level For Kapsch product	Interference Level Reported By NextNav	Notes
Reader Susceptibility	TDM DL	-67	-23	MRFMS
	TDM UL	-31	-26	MRFMS
dBm conducted	6C DL	-35 , -20	-40	MRFMSP 1.5 / 2.0 MHz (1)
	6C UL	-33 , -17	-23	MRFMSP 1.5/ 2.0 MHz (1)
worst model	SeGo DL	-11	>-3	MRFMS
	SeGo UL	-15	>-3	MRFMS
Transponder Susceptibility	TDM DL	-14 , -18	>-24	2 nd value is exterior transponders
	TDM UL	-7 , >+3		
dBm(i)	6C DL	-24		Same for both windshield and headlamp transponders
	6C UL	-25		
Average of models tested	TDMA DL	-36	Not measured	Only windshield transponders exist
	TDMA UL	-17		
Transponder Current threshold	TDM DL	-18 , -19	Not measured	2 nd value is exterior transponders
	TDM UL	-11 , >+3		Values for 1.5X current increase
dBm(i)	TDMA DL	-28		Onset of 300x current increase
	TDMA UL	-8		

Note (1) – 2 values reported are for different reader carrier frequency offsets from the sub-band edge.

Table 6-14: Path Model Specific MAPL

	Model	UMa	RMa	SMa	UMi	
Link Loss (max)	UE-BS (1)	143.2				dB
BS Margins	(2)	21.38	23.94	23.94	23.71	dB loss
MAPL	UE-BS	120.9	118.4	118.4	118.6	dB
d2d	LOS	2082	2386	3200	1006	m
	NLOS	582	974	584	557	m

Note (1) : As per Verizon link budget

Note (2) : As per Verizon but adjusted for 3GPP NLOS shadow fading values

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6.4 First Stage Assessment Results Using the Laboratory Test Data

Table 6-15 summarizes the cases where there was 50% probability (i.e. no variances included) that the interference would exceed the 5% PER at wake-up with 100% LMS-5G traffic at maximum transmit power with the BS and the ETC devices pointed at each other at particular points within the cell radius and minimum BS distance of 100 m from the ETC device. Note these are for the averages of the transponder devices and typical LMS-5G BS EIRP.

The figures later show the most susceptible conditions are when the AVI site is within 100-300 m of the BS, except for the UMi cases which are more variable with ETC device height.

Table 6-16 summarizes the results for the threshold being exceeded for battery current thresholds for the same conditions.

Note although some cases state no issues, the low margins indicate there is probability of exceeding the limits when the statistics are included.

Table 6-15: Summary of First Stage Modelling Results

Source	Device	Protocol	Key points
BS at typical 66 dBm EIRP d2d min set as 100 m	Reader	TDM	Issues up to 5280 m LOS and 1020 m NLOS Worst 40.9 dB above threshold
		6C	Issues up to 336 m LOS, worst 8.9 dB above threshold No NLOS issues min margin 5.7 dB
		SeGo	No issues, min margin 15.1 dB
	Transponder	TDM	No issues min margin 1.7 dB
		6C	Issues up to 498 m LOS, worst 8.3 dB above threshold No NLOS issues min margin 5.5 dB
		TDMA	Issues up to 1163 m LOS and 270 m NLOS, worst 18.8 dB above threshold
UE at 23 dBm EIRP d2d min set at 0.2 m	Reader	TDM	Issues up to 7.4 m, worst 20.6 dB above threshold
		6C	Issues up to 8.0 m, worst 22.6 dB above threshold
		SeGo	Issues up to 3.0 m, worst 4.6 dB above threshold
	Transponder	TDM	Issues up to 0.3 m, worst 2.3 dB above threshold
		6C	Issues up to 4.0 m, worst 19.3 dB above threshold
		TDMA	Issues up to 1.3 m, worst 11.3 dB above threshold
BS as above d2d min set at 10 m UE as above d2d min set at 0.2 m	Transponder	TDM currents	Issues up to 179 m LOS and 16 m NLOS, worst 8.8 dB above threshold
		TDMA currents	Issues up to 722 m LOS and 89 m NLOS, worst 18.8 dB above threshold
		TDM currents	Issues up to 0.5 m, worst 5.3 dB above threshold
		TDMA currents	Issues up to 0.3 m, worst 2.3 dB above threshold

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Table 6-16: Summary of First Stage Modelling Results for Battery Current Threshold

Case	d2d range m	Margin or difference	Level dB
UMa-LOS BS-WSTAG TDM-WS	10 to 179	dif	2.3
RMa-LOS BS-WSTAG TDM-WS	none	mar	2.2
SMa-LOS BS-WSTAG TDM-WS	14 to 40	dif	0.8
UMi-LOS BS-WSTAG TDM-WS	10 to 115	dif	8.8
UMa-NLOS BS-WSTAG TDM-WS	none	mar	8.4
RMa-NLOS BS-WSTAG TDM-WS	none	mar	3.8
SMa-NLOS BS-WSTAG TDM-WS	none	mar	5.8
UMi-NLOS BS-WSTAG TDM-WS	10 to 16	dif	2.6
SMa-LOS BS-LPTAG TDM-LP	10 to 47	dif	1.3
SMa-NLOS BS-LPTAG TDM-LP	none	mar	9.7
FSPL UE-WSTAG TDM	0.2 to 0.5	dif	5.3
INH-LOS UE-WSTAG TDM	0.2 to 0.5	dif	4.1
INH-NLOS UE-WSTAG TDM	0.2 to 0.5	dif	4.1
UMa-LOS BS-WSTAG TDMA-WS	10 to 370	dif	12.3
RMa-LOS BS-WSTAG TDMA-WS	10 to 722	dif	7.8
1SMa-LOS BS-WSTAG TDMA-WS	10 to 588	dif	10.8
UMi-LOS BS-WSTAG TDMA-WS	10 to 199	dif	18.8
UMa-NLOS BS-WSTAG TDMA-WS	10 to 27	dif	1.6
RMa-NLOS BS-WSTAG TDMA-WS	10 to 70	dif	6.2
SMa-NLOS BS-WSTAG TDMA-WS	10 to 40	dif	4.2
UMi-NLOS BS-WSTAG TDMA-WS	10 to 89	dif	12.6
FSPL UE-WSTAG TDMA	0.2 to 0.3	dif	2.3
INH-LOS UE-WSTAG TDMA	0.2 to 0.2	dif	1.1
INH-NLOS UE-WSTAG TDMA	0.2 to 0.2	dif	1.1

The data in these tables was determined with the following.

Table 6-17 shows the Kapsch Product Minimum Required Path Loss (MRPL) determination for Base Station Emissions. Looking at the table we can see that the Reader TDM MRPL mean already exceeds the MAPL of the LMS-5G communications in Table 6-14. Therefore coexistence is unlikely for these links with current Kapsch equipment. Non withstanding we included the links in the modelling because it identifies the improvement required if coexistence is to be achieved.

For the other links we see that the MRPL mean is significantly less than the MAPL, therefore at the cell edge coexistence is very possible. To see if there is a risk of coexistence issues within the cell radius, the PL was computed over a range of d2d distances from the BS with azimuths pointed at each other.

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To this basic PL was added:

- The (normalized) antenna elevation gain profile Gelb(d) versus ground distance d2d of the NextNav identified BS antenna modelled using ITU F.1336-5 peak sidelobe levels, at azimuth angle $\Psi = 0$.
- For interference to the Reader the reader antenna gain G0e (accounting for 1 dB cable loss) and normalized elevation gain Gele(d).
- For Gele(d), we used the measured Kapsch IAG3 elevation gain profile, at azimuth angle $\Psi = 0$, but limited the off-axis suppression to 30 dB below the boresight gain, to account for ground and other reflections.
- UE and transponders all have elevation and azimuth gains set to 0 dB.

Note this means the equations become (see section 6.1.3):

$$PLS(d) = PL(d) - G0e - Gelb(d) - Gele(d) - N(0, \sigma C^2) - N(0, \sigma S^2) \quad [EQ\ 4]$$

$$MRPL = EIRP - (Sus(PER) + AvC) \quad [EQ\ 5]$$

And margin is given by MRPL-PLS(d).

The data plotted and analyzed has σC and σS set to 0 representing that the analysis is for the average of variances, i.e. 50% of the cases with BS and AVI pointed at each other.

This results in the curves in Figure 6-8 through Figure 6-10. As well as the PL curves, the legend in each figure identifies the minimum and maximum ground distance at which the PLS was less than the MRPL for each protocol and the amount the MRPL would need to improve to have no issues, or if it never went below MRPL the amount of margin it had.

Note a minimum distance d2d was set in performing this determination which is indicated in the plot titles.

Table 6-17: Kapsch Product Minimum Required PL (MRPL) From Base Station

	Protocol / Tag	Susceptibility dBm(i) (1)	MRPL (dB) (2)
BS EIRP dBmi		66	
RDR Susceptibility	TDM	-67 +3 σ 1.0	130 σ 1.0
Worst model	6C	-35 +3 σ 3.0	98 σ 3.0
dBm conducted	SeGo	-11 +9 σ 3.0	74 σ 3.0
Transponder Susceptibility	TDM WS	-14 +3 σ 0.9	77 σ 0.9
Average of devices tested	TDM LP	-18 +3 σ 0.9	81 σ 0.9
dBmi	6C	-24 +3 σ 2.5	87 σ 2.5
	TDMA	-36 +3 σ 0.9	99 σ 0.9
Transponder Current	TDM WS	-18 +3 σ 0.9	81 σ 0.9
Threshold	TDM LP	-19 +3 σ 0.9	82 σ 0.9
dBmi	TDMA	-28 +3 σ 0.9	91 σ 0.9

Note (1): The +<x> σ <y> defines <x> the average (AvC) and <y> the standard deviation (σC), see [EQ-4] and [EQ-5] above, and Table 6-9.

Note (2): The standard deviations are only applied in second stage analysis.

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Table 6-18 shows the Kapsch Product Minimum Required PL determination for User Equipment at Maximum Power.

As with the Base station cases, the PL for the UE was computed over a range of d2d distances from the Reader and from the windshield tag, resulting in the curves in Figure 6-11.

Table 6-18: Kapsch Product Minimum Required PL (MRPL) From UE

	Protocol / Tag	Susceptibility (1)	MRPL (dB) (2)
UE EIRP dBm		23	
RDR Susceptibility	TDM	-31 +6 σ 3.5	48 σ 3.2
	6C	-33 +6 σ 4.2	50 σ 4.2
Conducted dBm	SeGo	-15 +6 σ 4.2	32 σ 4.2
Transponder Average Susceptibility dBm(i)	TDM WS	-8 +6 σ 3.1	25 σ 3.1
	6C	-25 +6 σ 3.9	42 σ 3.9
	TDMA	-17 +6 σ 3.1	34 σ 3.1
Transponder Average Current Threshold dBm(i)	TDM WS	-11 +6 σ 3.1	28 σ 3.1
	TDMA	-8 +6 σ 3.1	25 σ 3.1

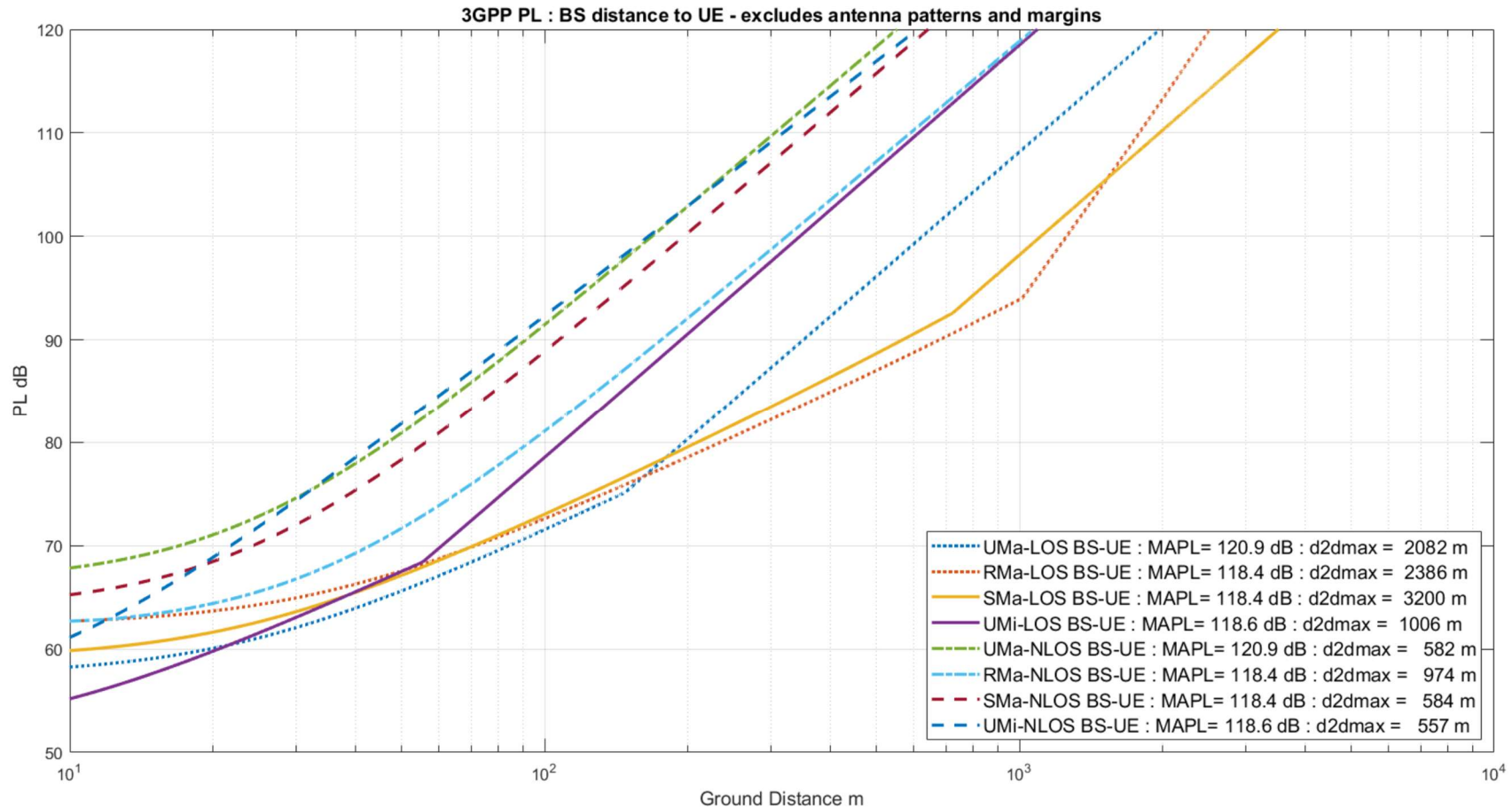
Note (1) The +<x> σ <y> defines <x> the average (AvC) and <y> σ C standard deviation (σ C), see [EQ-4] and [EQ-5] above, and Table 6-9.

Note (2) The standard deviations are only applied in second stage analysis.

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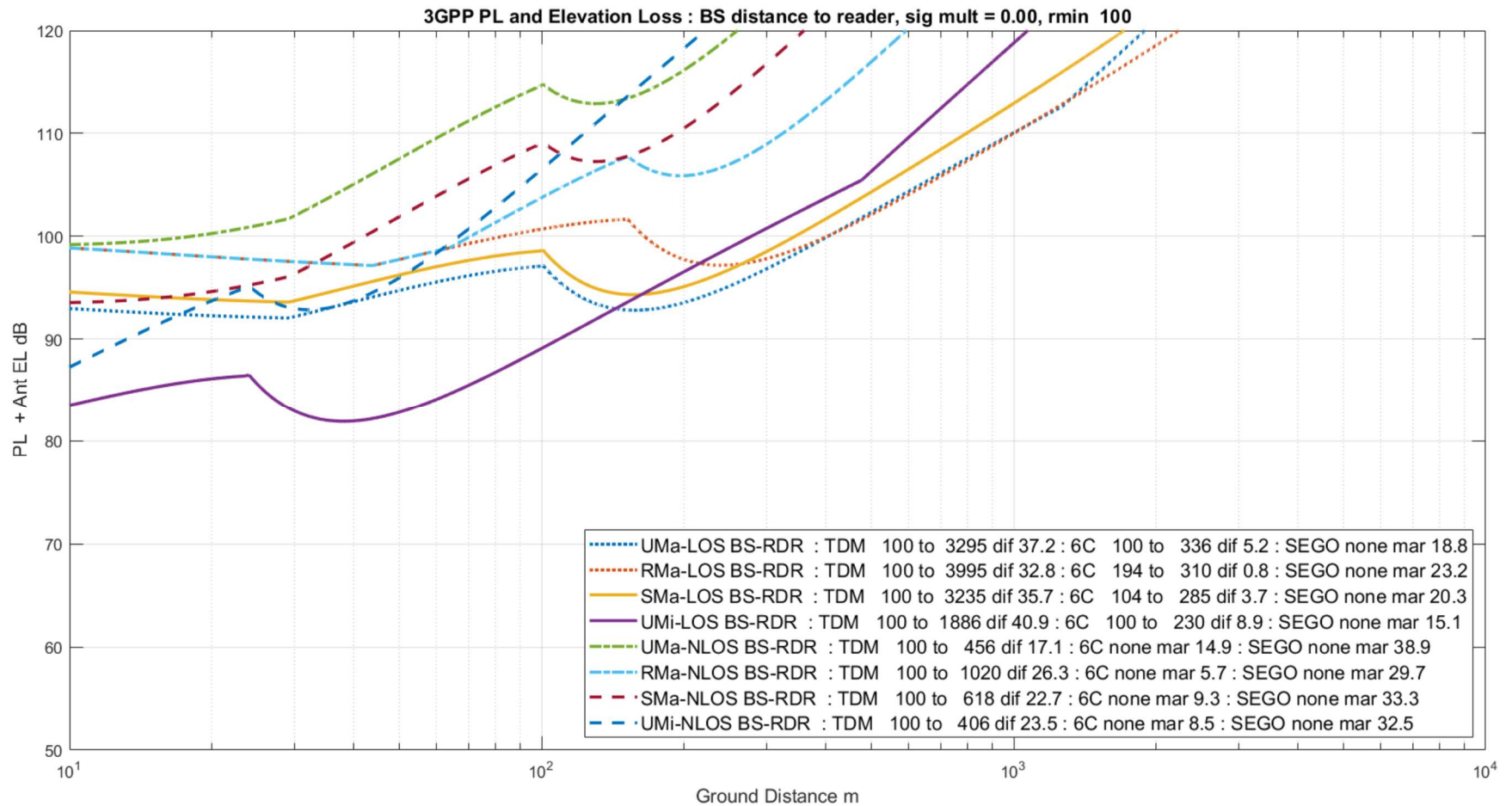
Figure 6-7: Path Loss PL only Vs BS Ground Distance to UE



Note: The larger change of SMa-LOS to SMa-NLOS than RMa-LOS to RMa-NLOS, is caused by the fact that while SMa and RMa have similar formulation, h and h_{bs} are lower, and W is higher resulting in the larger difference [see AD10] TR 38.901 table 7.4.1-1

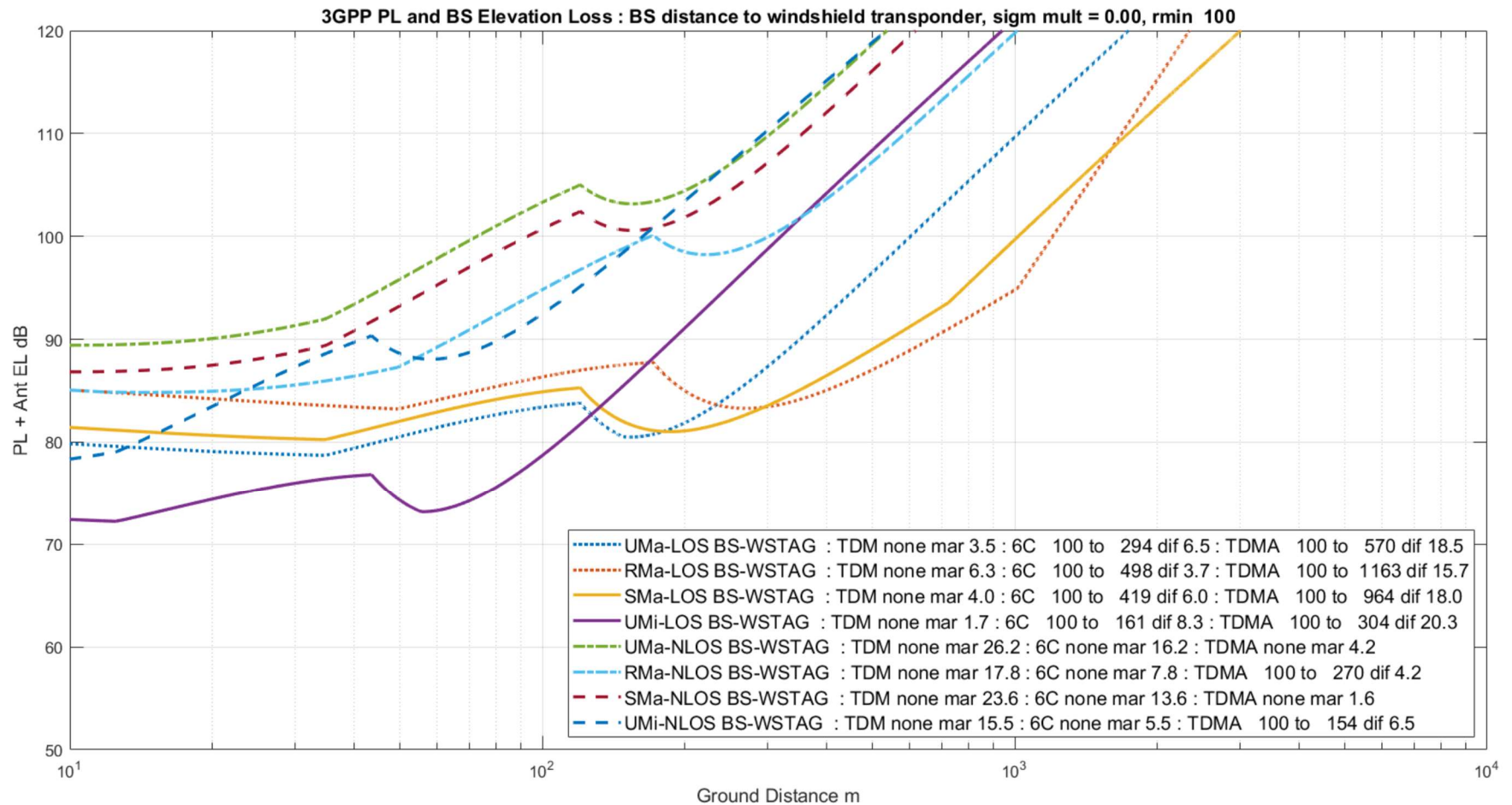
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Figure 6-8: Path Loss + Normalized BS Elevation Gain and Reader Elevation Gain Vs BS Ground Distance to ETC Reader



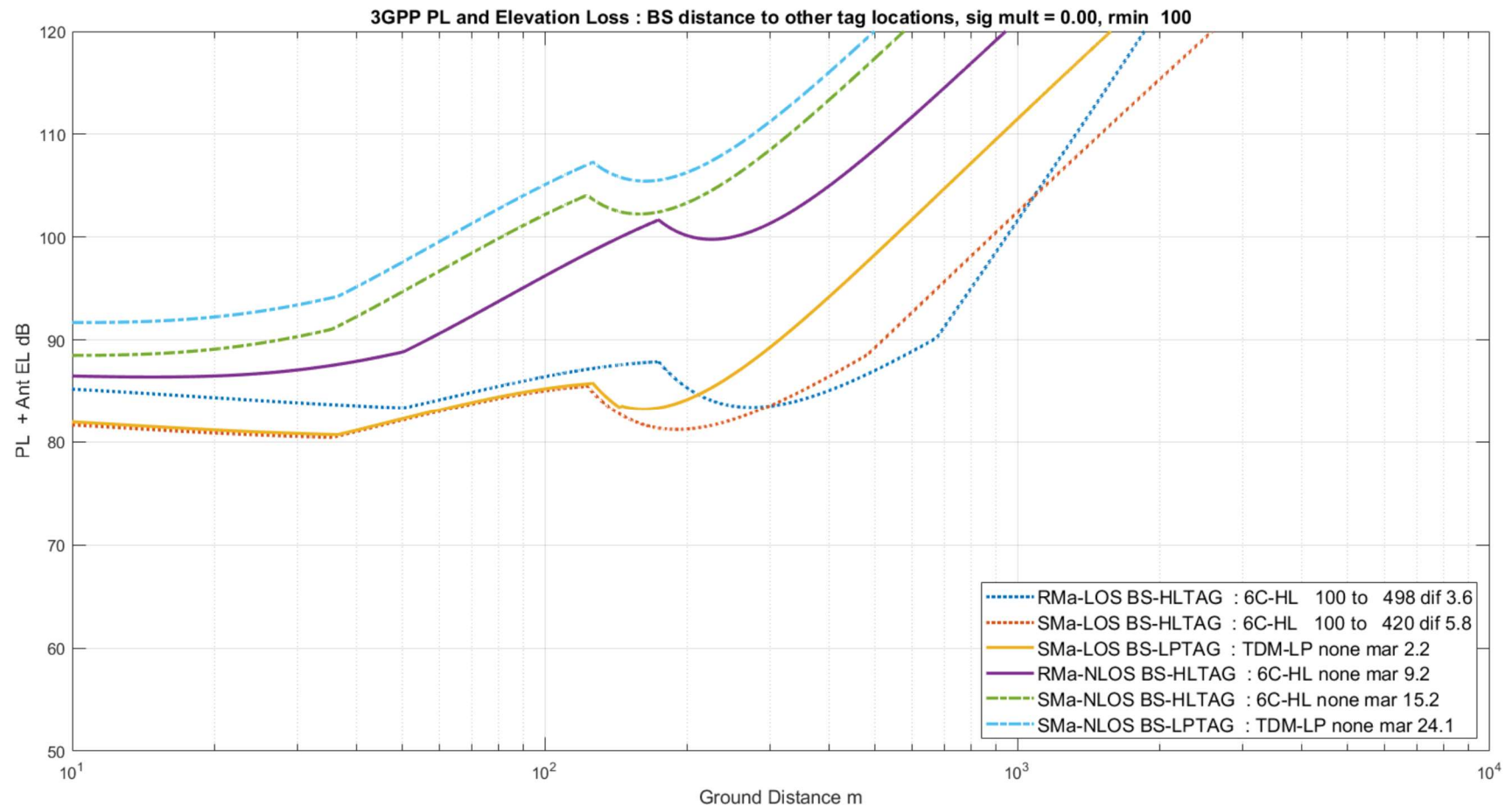
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Figure 6-9: Path Loss + Normalized BS Elevation Gain Vs BS Ground Distance to Windshield Transponders



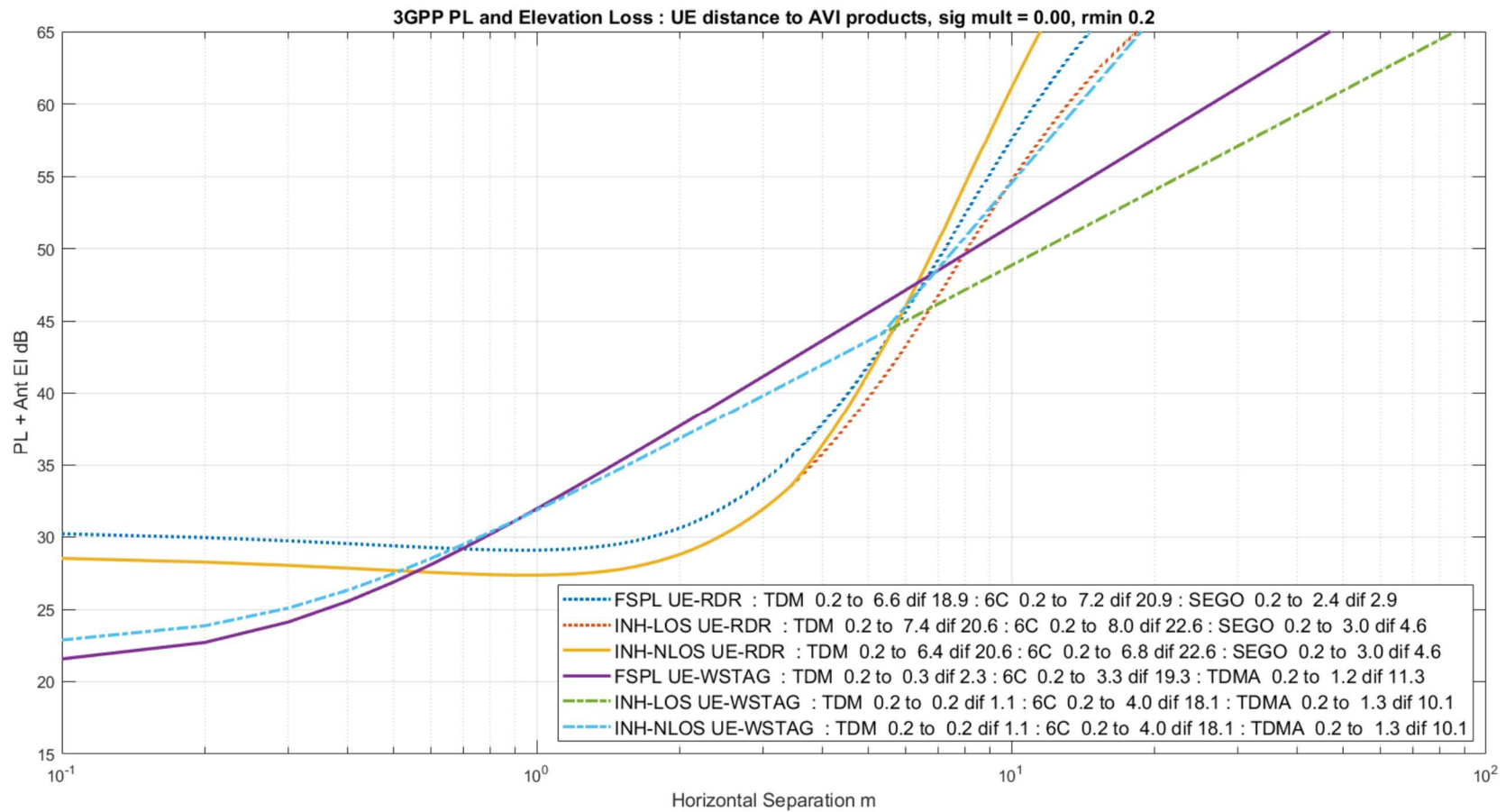
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Figure 6-10: Path Loss + Normalized BS Elevation Gain Vs BS Ground Distance to Other Transponder Locations



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Figure 6-11: Path Loss and Reader Antenna Elevation Gain Vs Ground Distance : UE to AVI



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6.5 Second Stage Assessment

We treat interference at ETC sites and interference to increase battery currents separately.

For interference assessment at ETC sites we want to validate that with the statistical variations and azimuth angles added how the results change versus the first assessment and using this determine the probability that there could be an AVI site located in the regions flagged by the first assessment assuming random BS and ETC site distributions.

For battery current assessment the concern is how long a transponder could stay in the regions where the current threshold is exceeded.

For both cases we focus on the Base station interference, given it has much higher activity (loading) factors. Further we look primarily at the transponder cases since it may be possible to improve reader susceptibility performance by firmware updates but the same is not true for transponders.

For the cell radius probability, we used the NLOS d2dMax values reported in Figure 6-7 as the cell radius limit.

Note that the intention herein is not to provide an exhaustive set of second stage analysis, but merely to confirm if the coexistence issues identified in the first stage analysis are meaningful under statistical conditions.

6.5.1 Computation Model For Second Stage Assessment

The first stage modelling assumed the BS and ETC device azimuth angles toward each other were small, the variances of shadow fading and device susceptibility were ignored, and no probabilities were assigned to the d2d between the BS and the AVI site. To determine the probability of any site failing to meet the interference target assuming random placement of BS and AVI sites we need to construct a combined probability model. We first define that there are 2 probabilities:

- Prad(d) – the probability of the ground distance separation between BS and AVI d2d being at a value d within the cell radius. Note that Prad(d) is dependent on knowing the cell radius. Also we start from the premise that the ETC site will be ≥ 100 m from the BS.
- Pexd(d) which is the probability at each ground distance of the interference exceeding the target required by taking the PLS and the probability distribution for each of the variables.

We revise the path loss equation to be become :

$$\text{PLS}(d2d) = \text{PL}(d2d) - G0e - \text{Gelb}(d2d) - \text{Gele}(d2d) - \text{Gazb}(\text{Pazb}(\theta)) - \text{Gaze}(\text{Paze}(\Psi)) - N(0, \sigma C^2) - N(0, \sigma S^2) \quad [\text{EQ 6}]$$

$$\text{Dist} = \text{Gazb}(\text{Pazb}(\theta)) + \text{Gaze}(\text{Paze}(\Psi)) + N(0, \sigma C^2) + N(0, \sigma S^2) \quad [\text{EQ 7}]$$

Where:

The first 4 terms of PLS(d2d) are the first stage assessment curves, with

- PL(d2d) is the 3GPP PL formulation for loss at ground distance d2d
- G0e is the boresight gain for the AVI device
- Gelb(d2d) and Gele(d2d) are the normalized elevation gains of the base station and ETC device respectively in the direction of the other equipment at the ground distance d2d.

Gazb(θ) and Gaze(Ψ) are the normalized azimuth gains vs angle of the base station and ETC device respectively in the direction of the other equipment.

Pazb(θ) is the probability distribution for the azimuth angle θ from the base station sector boresight to the ETC site; which for a sector antenna is over the range ± 60 degrees.

Paze(Ψ) is the probability distribution for the azimuth angle Ψ from the boresight of the ETC device to the Base Station. As discussed in section 6.2.4.4 we approximate for analysis purposes a limited azimuth range of ± 90 degrees of the AVI antenna (i.e. forward hemisphere only).

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- Note that since the reader elevation down-tilt is very high, if we were performing BS-Reader second stage analysis, since the reader-BS elevation relationship in the first stage modelling has the reader antenna off-axis gain set at analysis maximum 30 dB below boresight gain, therefore Gaze(Ψ) would have been set to zero.

Shadow fading $N(0, \sigma S^2)$ from the 3GPP models.

Device MRPL distribution $N(0, \sigma C^2)$ from Table 6-17.

We construct a CDF for Dist and then solve for each d2d the probability $P_{\text{exd}}(d)$ of exceeding the MRPL at that d2d. Then we combine that with the probability distribution $\text{Prad}(d)$ to come up with a single overall probability for the analysis case.

There is no closed form solution for the probability distribution $P_{\text{exd}}(d)$.

Note as discussed in section 6.2.5 for the AVI sites the 3GPP LOS probability models will severely underestimate the probability of BS-readers being in LOS relationship and therefore the 3GPP LOS probability is not included for site interference. However it is more likely valid for battery current analysis and is included for that.

6.5.2 AVI Site Assessment for BS Interference

For the first case we chose to analyze the 6C windshield transponder under UMa path conditions. This has a peak interference/5%PER threshold of 6.5 dB and exceeded the threshold from the (assumed) minimum of 100 m up to 294 m. The results of the second stage analysis are shown the following figures:

- The upper plot of Figure 6-12 shows the first stage model data for UMa-LOS, repeated from Figure 6-9, with the MRPL for the average measured sensitivity of Kapsch 6C transponders and the cell radius limits determined for UMa-NLOS and MAPL (see section 6.1.2). The lower plot shows the margin versus MRPL.
- Figure 6-13 shows the gain patterns for the antennas and the resulting probability distribution of gain over the sector.
 - The base station gain probability combines the power from the primary sector antenna plus power from the adjacent sector antennas.
 - The focus in this analysis is the transponder and we make a simplifying assumption that when the transponder ideal azimuth gain is 20 dB below boresight gain we can assume no contribution for azimuth angles outside this. We compensate for this by determining what percentage of the azimuth angle is outside this range, and use this later as the base value in constructing the CDF.
 - As shown in the figure approximately 6.4% of the transponder azimuth range lies outside the +/- 20 dB limit.
- Figure 6-14 shows the combining of all the probability distributions and the cumulative distribution.
- Figure 6-15 shows the overall results for $P_{\text{exd}}(d)$ and then the combination with $\text{Prad}(d)$ quantized to 2.5 m radius increments.

The plots show the primary contributions to overall probability are not much different than the range determined in the first stage modelling, and therefore Kapsch assumes the first stage modelling is sufficient at this time to identify there will be coexistence issues.

This particular case analysis resulted in a 8.25% probability that there will be ETC locations within UMa sites with line of sight to a base station in one travel direction (potentially of both directions at the site) where the interference will exceed the 5% PER at wake-up for LMS-5G interference at the ETC site.

Because of this, even using a minimum 100 m separation is insufficient and it would be necessary to check each site for coexistence potential before deployment, either LMS-5G to existing ETC site, or in future ETC site to LMS-5G site, and coexistence management would be required.

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Figure 6-12: UMa LOS BS to 6C Windshield Transponder Vs Ground Distance at Az=0, $\sigma=0$

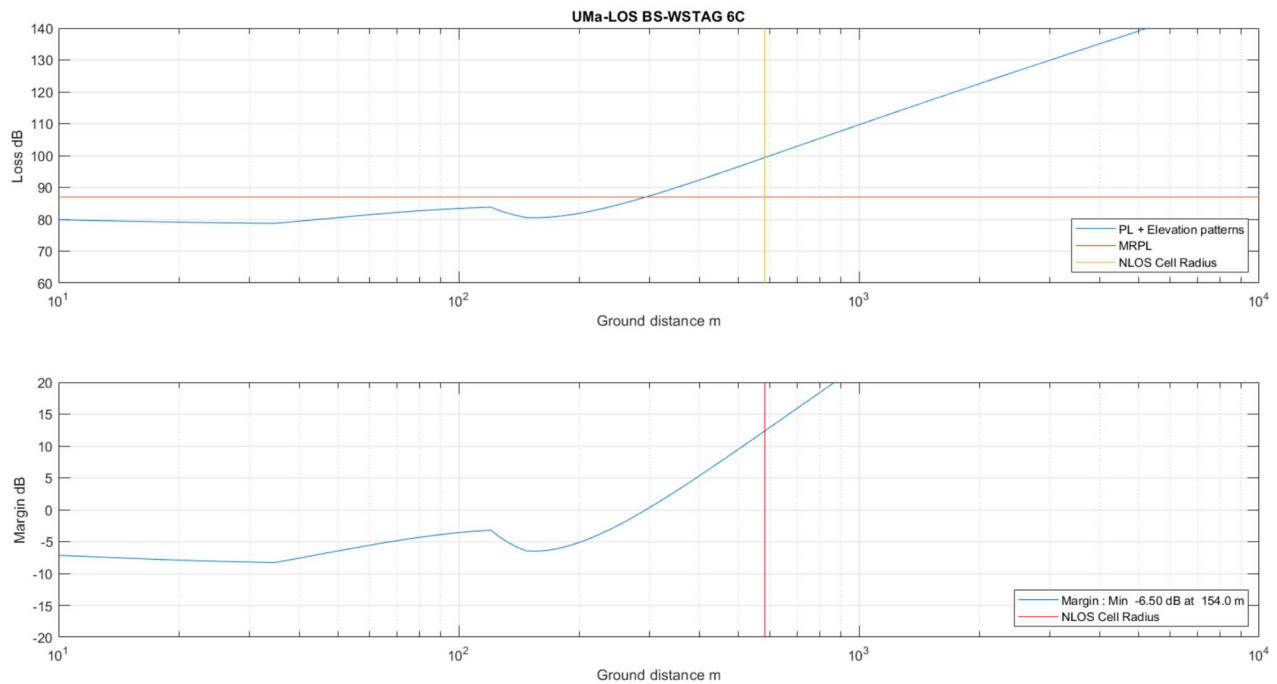
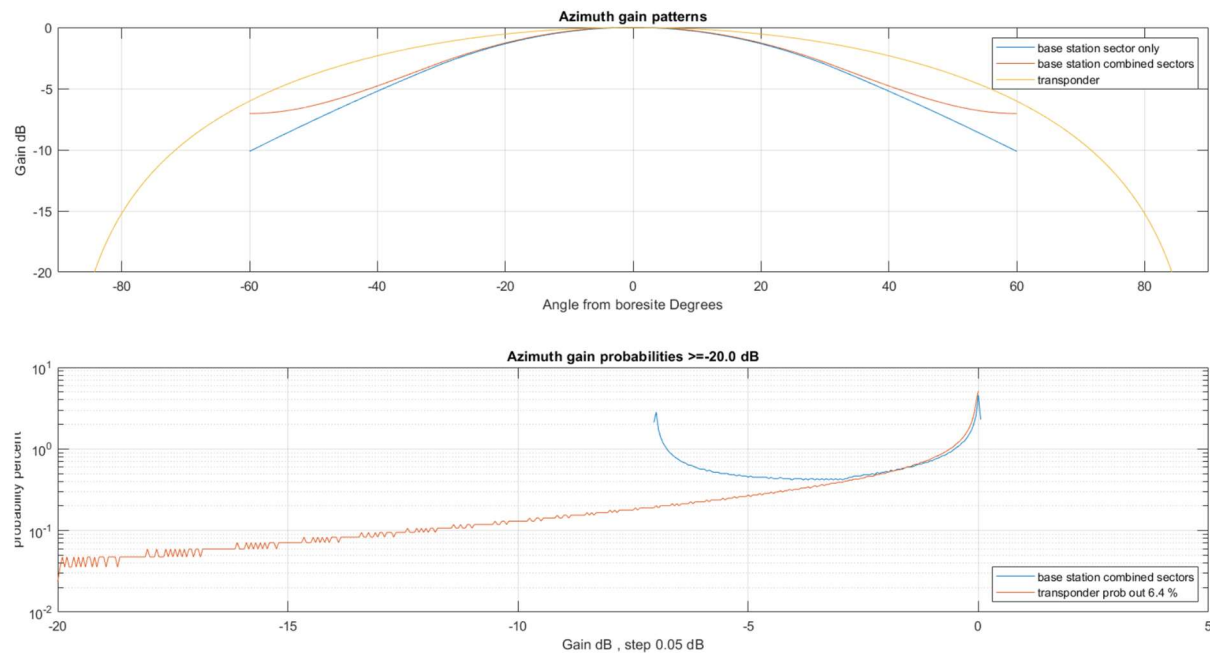


Figure 6-13: Azimuth Gain Patterns and Probability Distributions



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Figure 6-14: Cumulative Probability Distributions for PLS

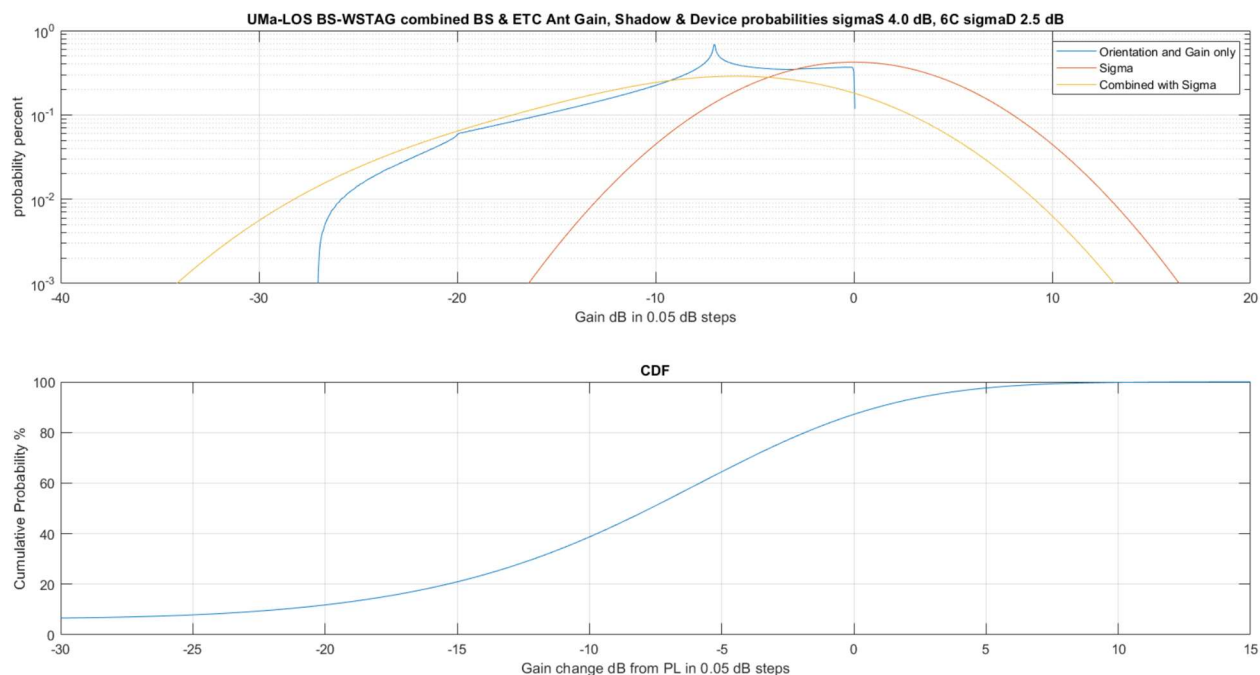
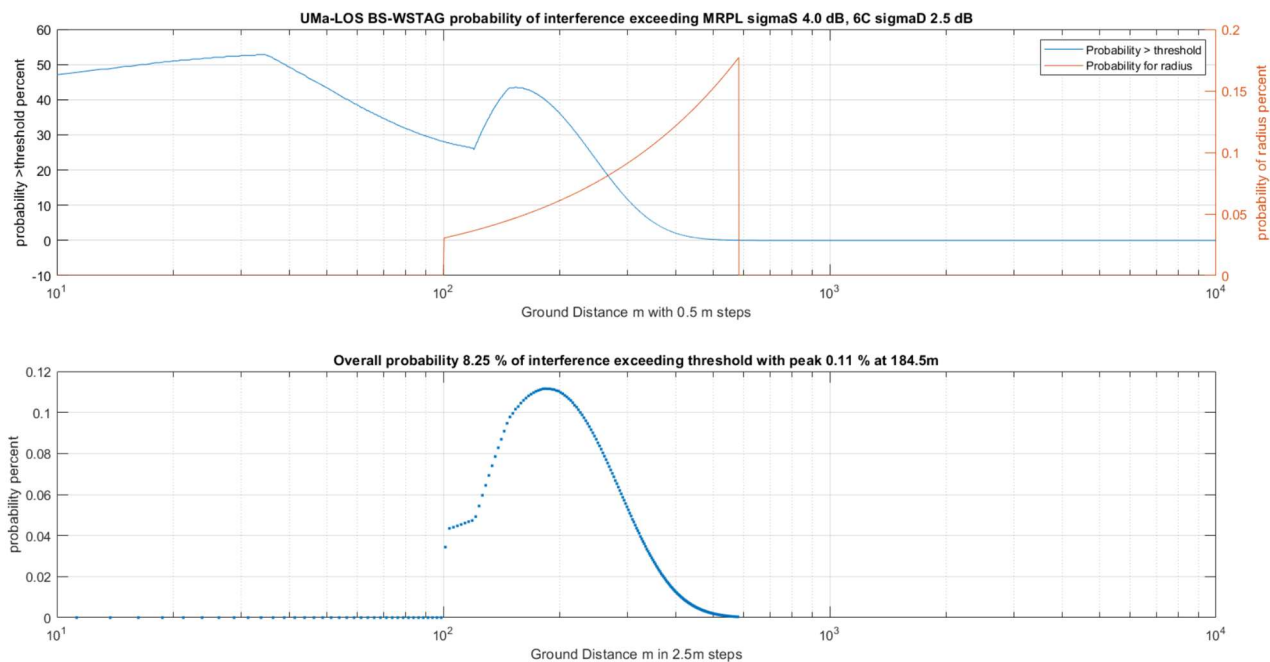


Figure 6-15: Overall Probability Of Interference Exceeding > 0.5% Packet Error Rate Threshold



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6.5.3 TDM Battery Current Increase from BS Interference Assessment

Table 6-19 repeats some key battery current results from Table 6-16 for clarity, and also tabulates the results of second stage analysis showing the overall probability.

Note this probability is the probability that with random transponder locations over all base station sectors that the locations will exceed the current threshold for 1.5x increase in the battery current.

Consider the UMi-LOS case for TDM tags. This PL and margin can be seen in Figure 6-16.

The computation used the similar models as the AVI site interference assessment, but the 3GPP LOS probability is also factored in as it is assumed valid for the battery threshold analysis.

We see in Figure 6-17 that with the statistics added the margin of overshooting by 8.8 dB in LOS conditions became a cumulative probability over a UMi sector combining LOS and NLOS results of 0.6%, when factoring in the 3GPP LOS probability. Also note that even when first stage analysis indicates margin, when the statistics were factored in there is a similar magnitude probability of locations in the other 3GPP path models.

These probabilities may seem small, but they are just the probabilities of locations of transponders having the battery current increased to at least 1.5x normal, with random BS and transponder relationships, and should not be interpreted to be the probability of life reduction, not indications of the net reduction in life. Note that the current increase in these locations can be much higher (up to 1000x) for small increases in interference above the threshold (see section 5.4).

The biggest issues with trying to determine the loss of battery capacity is predicting how often the situation will occur which is dependent on the vehicle travel, and by how much the current will increase when it does occur. There is no closed form solution for this, and there is no clear model to determine this.

Consider vehicles which are regularly parked on the street or on driveways. If this parking location corresponds to the one of the sensitive locations the transponder life will be drastically reduced.

Also consider vehicles traveling along highways and city streets encountering LMS-5G sites with LOS to the transponders, e.g. as discussed in section 6.2.5. The transponders will be in the sensitive regions for each BS encountered much longer than they would be in the toll sites, and could encounter multiple such BS per vehicle trip, so their life would be eroded much faster than normal.

Note also that there are contractual requirements on transponder life and failure rates and even 0.5% will cause those requirements to be violated. To prevent this would require TDM transponder designs to be updated to prevent this life loss.

Table 6-19: Key Modelling results for TDM Battery Current Threshold Locations

Case	d2d range m	Margin or difference	Level dB	Overall probability of locations %
UMa-LOS BS-WSTAG TDM-WS	10 to 179	Dif	2.3	0.39% + 0.00007%
UMa-NLOS BS-WSTAG TDM-WS	none	Mar	8.4	
RMa-LOS BS-WSTAG TDM-WS	none	Mar	2.2	0.56% + 0.0008%
RMa-NLOS BS-WSTAG TDM-WS	none	Mar	3.8	
SMa-LOS BS-WSTAG TDM-WS	14 to 40	Dif	0.8	0.98% + 0.0133%
SMa-NLOS BS-WSTAG TDM-WS	none	Mar	5.8	
UMi-LOS BS-WSTAG TDM-WS	10 to 115	Dif	8.8	0.59% + 0.0093%
UMi-NLOS BS-WSTAG TDM-WS	10 to 16	Dif	2.6	

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Figure 6-16: Umi-LOS BS to TDM Transponder Current PLS Vs Distance at $Az=0$, $\sigma=0$

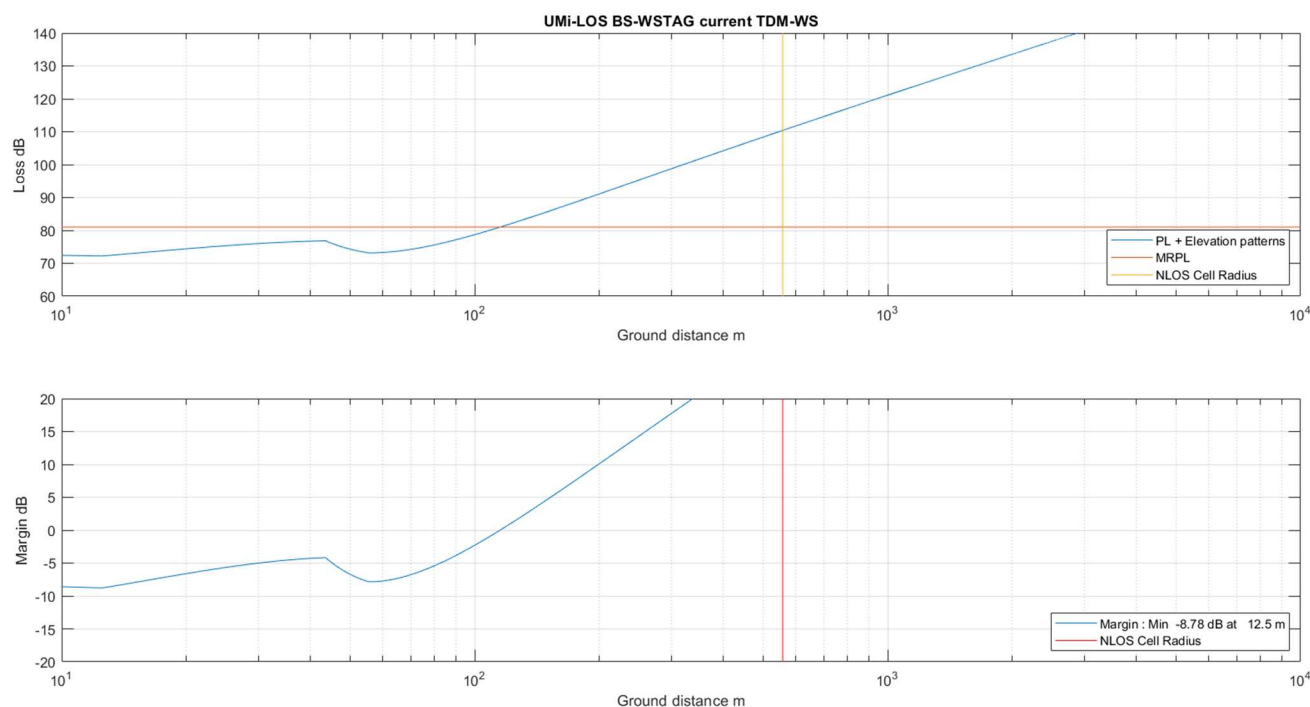
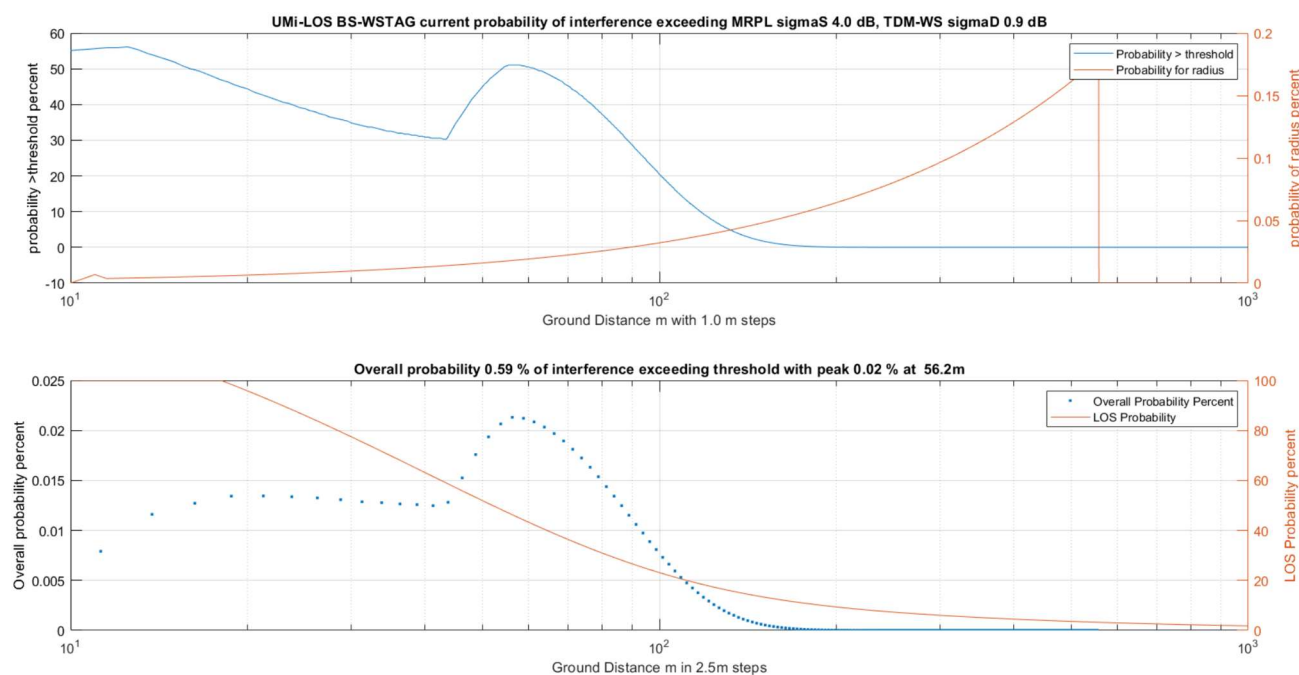
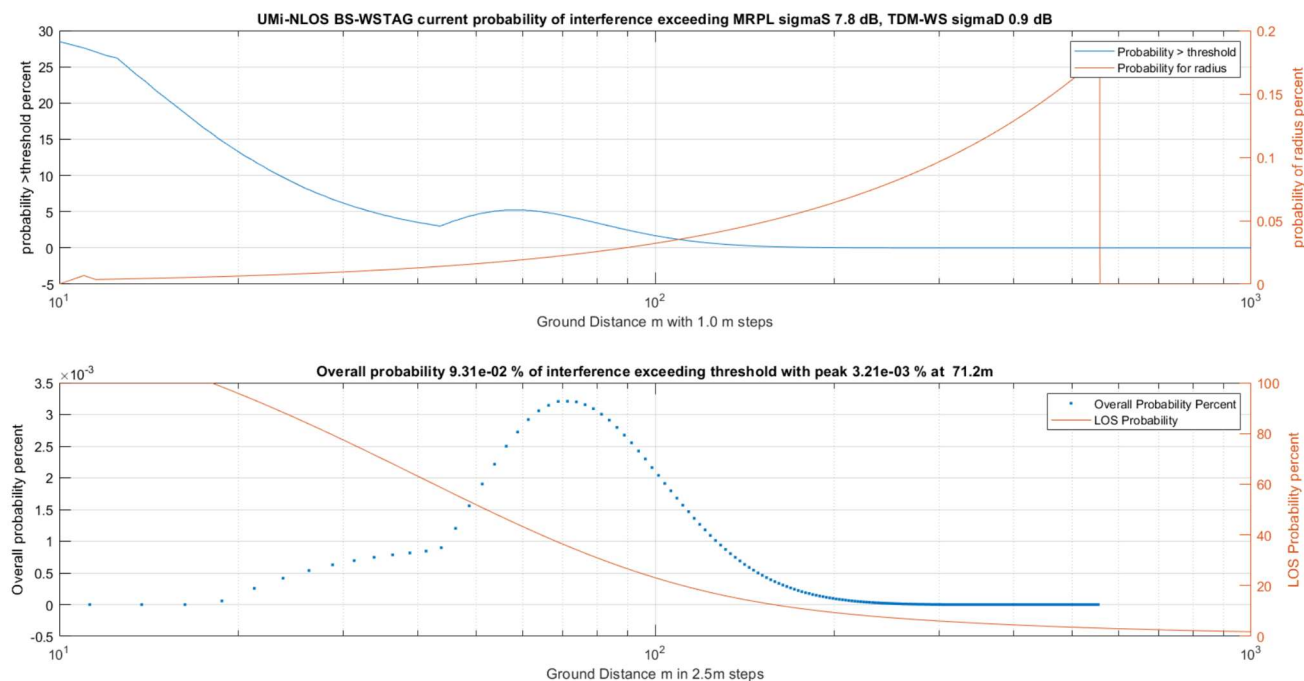


Figure 6-17: UMi-LOS BS to TDM Transponder Current Overall Probability Of Exceeding Threshold



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Figure 6-18: UMi-NLOS BS to TDM Transponder Current Overall Probability Of Exceeding Threshold



6.5.4 TDMA Battery Current Increase from BS Interference Assessment

A similar analysis was carried out for TDMA transponders, and the results reported in Table 6-20.

Note that these probabilities are percentage of locations inside base station sectors where the current increase will jump to 300x normal, and should not be interpreted to be the probability of life reduction, not indications of the net reduction in life. The high probabilities of locations exceeding threshold means that transponder life will be severely impaired and it would be necessary to redesign TDMA transponders to prevent this.

Plots are shown for the RMa cases and show that the issues are likely to be up to significant distances from base stations. The data indicates that the effects will occur in all the 3GPP path models.

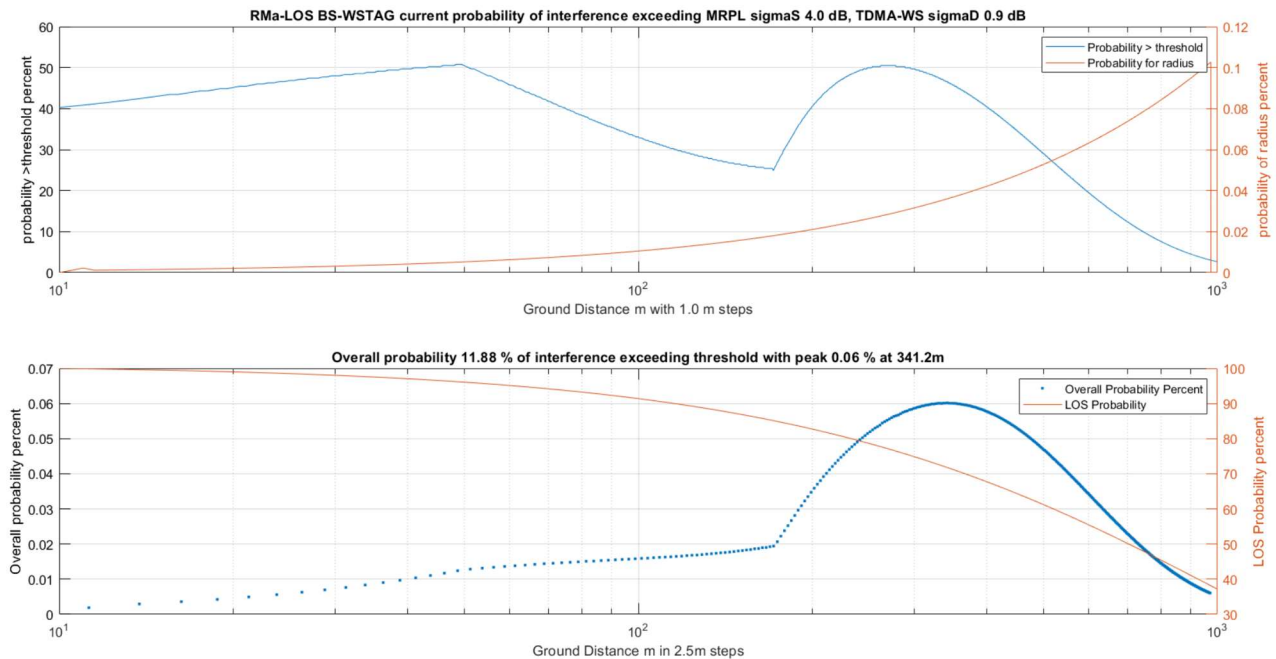
Because TDMA transponders are used for CVO in commercial transport vehicles and these regularly travel long distances and will likely encounter many base stations where the LOS probability is higher than the 3GPP model predicts (see section 6.2.5) transponder life will be eroded at even higher rates than the location probability indicates.

Kapsch TrafficCom Report of Laboratory Testing and Impact Analysis for Kapsch NM-LMS Product against Interference from NextNav Proposed Usage of the LMS Spectrum

Table 6-20: Key Modelling Results for TDMA Battery Current Threshold Locations

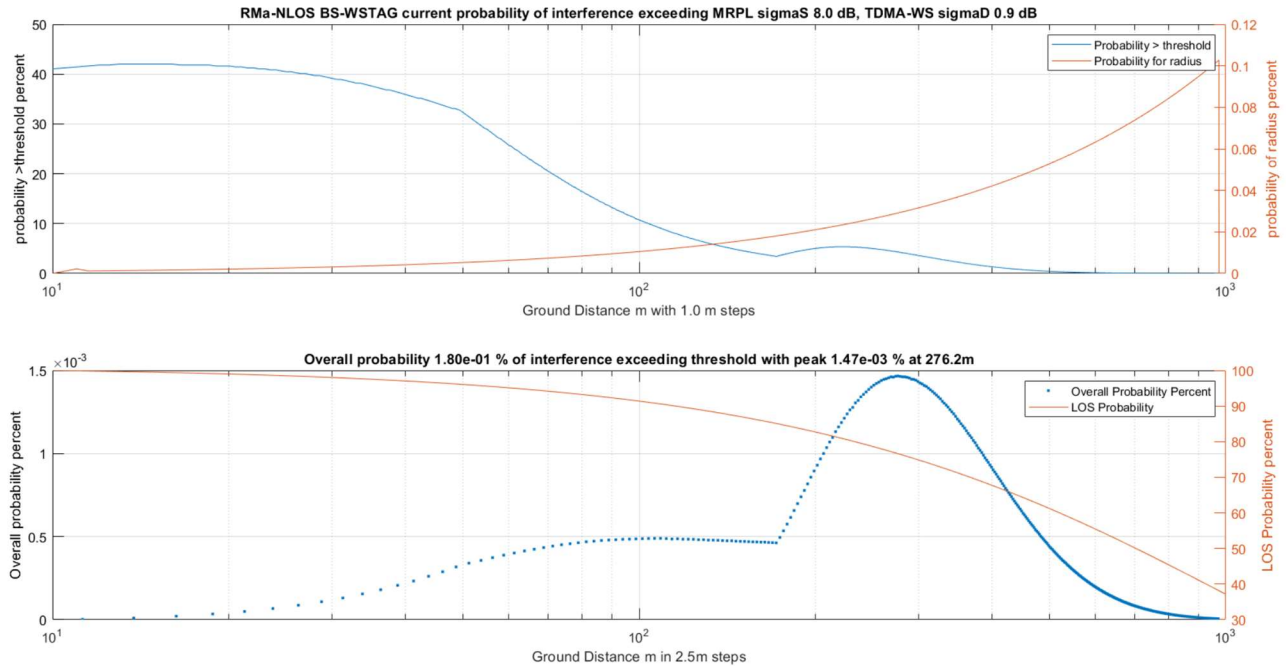
Case	d2d range m	Margin or difference	Level dB	Overall probability of locations%
UMa-LOS BS-WSTAG TDMA-WS	10 to 370	Dif	12.3	2.8% + 0.0055%
UMa-NLOS BS-WSTAG TDMA-WS	10 to 27	Dif	1.6	
RMa-LOS BS-WSTAG TDMA-WS	10 to 722	Dif	7.8	11.88%+ 0.18%
RMa-NLOS BS-WSTAG TDMA-WS	10 to 70	Dif	6.2	
SMa-LOS BS-WSTAG TDMA-WS	10 to 588	Dif	10.8	9.39% + 1.66%
SMa-NLOS BS-WSTAG TDMA-WS	10 to 40	Dif	4.2	
UMi-LOS BS-WSTAG TDMA-WS	10 to 199	Dif	18.8	1.66% + 0.92%
UMi-NLOS BS-WSTAG TDMA-WS	10 to 89	Dif	12.6	

Figure 6-19: RMa-LOS BS To TDMA Transponder Current Overall Probability Of Exceeding Threshold



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Figure 6-20: RMa-NLOS BS to TDMA Transponder Current Overall Probability Of Exceeding Threshold



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NextNav Proposed Usage of the LMS Spectrum

7. CONCLUSIONS

The study shows that in contrast to the NextNav statements, there is significant risk to the ETC and CVO operations with currently deployed equipment if the NextNav proposal for rule change is accepted.

The analysis herein and conclusions are limited to the Kapsch equipment and should not be interpreted to mean that they apply to equipment from other AVI vendors.

There were significant differences between the NextNav reported susceptibility data and the Kapsch device susceptibilities. There are some also disparities on items such as vehicle penetration loss, inclusion of polarization loss and off-axis antenna gain, and in particular the generalization to cover random BS-ETC device relationships, that introduce differences between the co-existence analyses. Section 2.5 outlines specific issues identified with the NextNav submissions.

The Kapsch analysis showed that all lanes (in a direction) would be affected by the LMS-5G interference to the same degree at the same time since the 3GPP shadow fading correlation distance is much larger than a few lanes of the toll sites. There was little improvement in 6C or SeGo as the carrier frequency was moved through the sub-band, except at the sub-band edge, so channel frequency could not be used to mitigate the LMS-5G interference effects at a site.

In this report a statistical approach has been taken for analysis of the co-existence and models were developed on key items, so that it is not dependent on using assessment of a particular geographic area but instead are generalized to just using the 3GPP and ITU models for assessment.

The analysis was carried out assuming first a blanket minimum base-station to ETC site distance of 100 m. If there were no issues beyond this distance then co-existence could be easily managed. Unfortunately this is not the case.

The first stage modelling, which used BS and AVI devices pointed at each other and used average device performance and no statistical variations, exposed that there are significant issues.

- Based on the Kapsch reader TDM results, Kapsch predicts that the MRFMS radios will need to be replaced and design changes made to the MRFMSP and MPR4.1 radios to substantially improve the TDM performance, if coexistence is to be achieved. Kapsch believes at this time that this can be done with only firmware changes and no hardware changes, but cannot confirm this without actually performing and validating the redesign.
- The Kapsch reader 6C results indicate that the carrier to sub-band edge spacing will need to be increased to 2 MHz where currently ≤ 1.5 MHz is required for emission mask compliance for MRFMSP and MPR4.1. This places the ability to achieve 4 carriers with 2.5 MHz in the proposed frequency plan at risk, and the KPIs on sites at risk. This leaves no margin for adjusting due to interference from other sources. Changes may be needed to the MRFMSP and MPR4.1 radio firmware to improve this also.
- On the ETC transponder side, the results are in total contrast to the analysis by NextNav. Despite similar measured average susceptibility for 6C transponders (-24 dBm), the results herein show coexistence issues up to 498 m from the typical BS EIRP in LOS conditions and up to 8 m separation of the windshield transponder from the UE (at maximum UE transmit power).
- TDM transponders, which have less susceptibility than reported by NextNav, had small margins to the base station interference in the ETC sites, but the TDMA transponders definitely were affected and would have to be redesigned to mitigate this.
- In most cases the region 100 m- 300 m from the base station is where the interference issues peak, except for UMi where the peak is below 100 m.

The second stage modelling was introduced to identify if statistics support the first stage assessment that coexistence risks exist by evaluating the probability of BS-AVI locations sites having such issues, including assuming random relationships between LMS-5G equipment and the AVI equipment. Note the cell radius is a factor in that probability, but there are no reference data from NextNav on this. FCC National Broadband Map links budgets were used to develop some cell radius values. For BS interference the cases analyzed were sufficient to prove that the first stage analysis is adequate to identify interference risk at the ETC sites. The specific cases analyzed showed that:

**Kapsch TrafficCom Report of Laboratory Testing and Impact Analysis for Kapsch NM-LMS Product against Interference from
NextNav Proposed Usage of the LMS Spectrum**

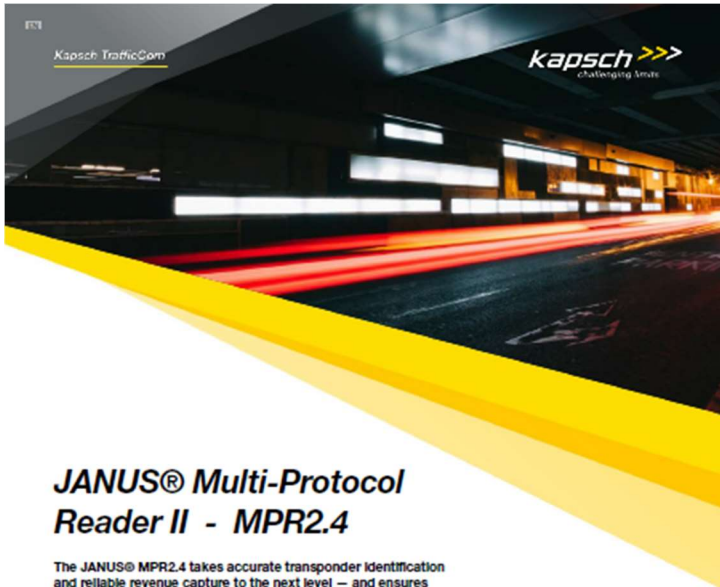
- At 100% DL traffic for the case analyzed there is a 8.25% probability that there will be sites where 6C transponders will experience interference above the 5% packet error threshold due to the base station transmissions with a peak of problems at 185 m from the base station. This would therefore imply deployments will require site by site coexistence analysis.
- On the battery current side, both the TDM and especially the TDMA transponders have significant risk of life being reduced by the presence of LMS-5G, and would have to be redesigned to mitigate this.

Kapsch TrafficCom Report of Laboratory Testing and Impact Analysis for Kapsch NM-LMS Product against Interference from
NextNav Proposed Usage of the LMS Spectrum

Appendix A. KAPSCH AVI UHF PRODUCT DATA SHEETS

The following information is replicated from [RD13]

A.1. MPR2.4 Data Sheet



JANUS® Multi-Protocol Reader II - MPR2.4

The JANUS® MPR2.4 takes accurate transponder identification and reliable revenue capture to the next level – and ensures your interoperable future, with the option of redundancy.

JANUS Multi-Protocol Readers are built on a highly flexible architecture to provide highly scalable systems, and support major North American industry tolling protocols.

The reader is the industry's only truly redundant multi-protocol reader with eight individual RF channels for the most flexible and cost effective deployment. JANUS MPR2.4 reader provides ease of installation, integration, maintenance, protocol selection, and facilitates a smooth transition to an interoperable future.

The JANUS MPR2.4 reader makes very efficient use of available communication time. Flexible protocol configuration allows for prioritizing time sharing of protocols, thereby maximizing multiprotocol capture for your particular environment. These configurable readers add multi-protocol capture capability to new or existing lanes. A single MPR2.4 reader can support up to eight RF channels for lane based tolling or AET (All Electronic Tolling), and sync to previous generation readers.*

Key Features

- No extra license fees - Single price for all protocols and antenna ports.
- High power output (up to +36 dBm).
- Tested in multi-protocol mode up to 100mph.
- Ability to remotely access, diagnose, download data and update software/firmware.
- Buffered transaction capacity up to 1,000,000 transactions.
- Ensures precise lane reads. Provides a flexible platform facilitating multiple transponder deployment strategies and smooth migration from legacy protocols.
- Field software upgradable – JANUS MPR2.4 adapts and supports your operational strategy upgrades. It allows for the possible addition of protocols.*
- Protects operator technology investment as the market evolves to national interoperability.

Doc No: Kapsch-KTC-D8-Janus_MPR2.4-110223_EN

Kapsch TrafficCom Report of Laboratory Testing and Impact Analysis for Kapsch NM-LMS Product against Interference from NextNav Proposed Usage of the LMS Spectrum

Technical Features

Industry-proven voting algorithm ensures accurate lane identification.
Highly redundant architecture sustains the revenue collection process and ensures uptime, with a higher confidence level in performance.
Fully expandable to support additional lanes, including AET, by synchronizing additional readers.
Intuitive web interface that supports remote diagnostics, software update management, and system performance monitoring.

Dimensions (W x H x D)

19.0 in (48.3 cm) rack mount (10U height)
19.0 x 17.5 x 11.0 in / 48.3 x 44.5 x 27.9 cm

Weight

63 lbs. / 28.6 kg (without optional cabinet)

Input Power Consumption (with 8 RF modules)

115-230 VAC
350W (Redundant), 200W (Non-redundant)

RF Conducted Power

Max. +36 dBm (4W)

Operating /Storage Temperature

Operation:
-20 °F to +131 °F / -34 °C to +55 °C
-20 °F to +166 °F / -34 °C to +74 °C
* With circulating fans, meets NEMA TS-1

Storage:

-40 °F to +100 °F / -45 °C to +40 °C

Relative Humidity

5% to 95% (non-condensing)

Shock & Vibration

NEMA TS-1
Shock @ 10G in three planes
Vibration @ 5-30 Hz, 0.5G in three planes

Antenna Ports

Up to 8 antennas by installing individual RF modules - single RF channel per antenna.

Operating Frequency (Protocol specific)

902.5 to 903.5 MHz and 910 to 921.5 MHz

Communications Interface

Ethernet (10/100/1000Base-T) / RS232 / RS422

Regulatory

Federal: FCC Part 15 Class A
UL 60950-01
RF Module: FCC Part 90*
Industry Canada RSS137
* User obtained its license may be required for operation in your region (i.e. USA = FCC Part 90)

Supported Protocols

R - Road, RW - Road/White
Kapsch TDM (E-ZPass®) - RW
ISO 18000-63 (6C) - RW
ISO 18000-63 (6B) - R
ISO 18000-62 / 80 kbps (SeGo) - R
ISO 18000-62 / 31.25 kbps - R
ISO 10374 (ATA) - R

Lane Expandability

Supports synchronization with other Janus readers to support additional lanes.

RF Modules (MRFMS+)

MRFMS+ reader requires at least one RF radio (MRFMS+ module) to be installed. MRFMS+ modules are available as stand-alone or as lane kits that include antenna and other hardware.



Kapsch TrafficCom

is a provider of intelligent transportation systems in the fields of tolling, traffic management, smart urban mobility, traffic safety and security, and connected vehicles. As a one-stop solutions provider, Kapsch TrafficCom offers end-to-end solutions covering the entire value creation chain of its customers, from components and design to the implementation and operation of systems.

>>> www.kapsch.net

(*) Janus MRFMS+ supports a number of different protocol installations and features based upon customer requirements; contact sales@kapsch.net for more information.

This product contains technology licensed from Janus Systems LLC. A list of these patents can be found at www.kapsch.net/licenses.

Content subject to change without notice.

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Doc No.: Kapsch-KTC-036_Janus_MRFMS+_102020_01

Kapsch TrafficCom Report of Laboratory Testing and Impact Analysis for Kapsch NM-LMS Product against Interference from NextNav Proposed Usage of the LMS Spectrum

A.2. MPR4.1 Data Sheet



The image shows a Kapsch MPR4.1 Multi-Protocol Reader, a compact, silver-colored electronic device with multiple ports on the side. It is positioned on a surface with a yellow and grey geometric pattern. The Kapsch logo and 'challenging limits' tagline are visible in the top right corner of the image area. A small circular logo with a triangle and the text 'CERTIFIED' is also present near the device.

For decades, the JANUS Multi-Protocol Readers have taken accurate transponder identification and reliable revenue capture to the next level.

Kapsch is expanding its line of Reader products - the performance you expect, in a smaller package.

JANUS Multi-Protocol Readers are built on a highly flexible architecture to provide highly scalable systems, and support major North American industry tolling protocols.

The newest member of the Reader family is the Janus MPR4.1. A single channel, time-multiplexed multiple port reader that is ideal for single lane toll deployments or, using its multi-port capabilities, up to four lanes with a single reader.

The new MPR4.1 four-port reader is built on the same reliable, flexible foundation as the other Janus readers and offers the same level of performance you have come to expect while providing greater RF power which allows for longer cable lengths, multi-protocol selection including T21, and a new modern graphical interface (GUI). The new GUI provides users the same level of configuration and flexibility as previous generation JANUS Readers, but with a newer modern look.

Providing ease of installation, integration, maintenance, and protocol selection, the new JANUS MPR4.1 will be the reader of choice.

Key Features

- IC OmniAir Certified
- IP66 / NEMA 4 enclosure
- Tested in multi-protocol mode up to 100mph
- High power output (up to +33 dBm)
- Ability to remotely access, diagnose, download data and update software/firmware
- No extra license fees - Single price for all protocols and antenna ports. No need for licenses or keys to unlock protocols or ports
- Buffered transaction capacity up to 1,000,000 transactions
- Exclusive unique installation bracket

Doc No.: Kapsch-KTC-DS-Janus_MPR4.1-112223_EN

Kapsch TrafficCom Report of Laboratory Testing and Impact Analysis for Kapsch NM-LMS Product against Interference from
NextNav Proposed Usage of the LMS Spectrum

Technical Features

Industry-proven voting algorithm ensures accurate lane identification.
Fully expandable to support additional lanes, including AET, by synchronizing additional readers.
Intuitive web interface that supports remote diagnostics, software update management, and system performance monitoring.

Dimensions (W x H x D)

19.0 x 15.2 x 4.0 in. / 48.3 x 38.6 x 10.2 cm

Weight

17.6 lbs. / 8.1 kg

Input Power / Consumption

Max. 50W, 19-30 VDC

RF Conducted Power

Max. +33 dBm (2W)

Operating / Storage temperature

Operation: -34.6 °F to +165 °F / -37 °C to +74 °C
Storage: -40 °F to +185 °F / -40 °C to +86 °C

Relative Humidity

5% to 95% (non-condensing)

Enclosure

IP66 / NEMA 4

Shock & Vibration

NEMA TS-2
Shock @ 100 in three planes
Vibration @ 5-20 Hz, 0.5G in three planes

Antenna Ports

4, N-Type

Operating Frequency (Protocol specific)

902.5 to 903.5 MHz and 910 to 921.5 MHz

Communications Interface

Ethernet (10/100/1000Base-T)

Regulatory

6C OmniAir Certified (in multi-protocol mode)
FCC Part 90 subpart M
Industry Canada RSS137
FCC Part 15 Class A
- User obtained site license may be required for operation in your region (i.e. USA - FCC Part 90)

Supported Protocols

R - Read only - Read/Write
Kapsch TDM (E-ZPass®) - RW
ISO 18000-63 (6C) - RW
ISO 18000-62 (6B) - R
ISO 18000-62 / 80 kbps (8aG) - R
ISO 18000-62 / 31.25 kbps - R
ISO 10074 (ATA) - R
California Title-21 (T21) - R

Lane Expandability

Supports synchronization with other Janus readers to support additional lanes.



Installation

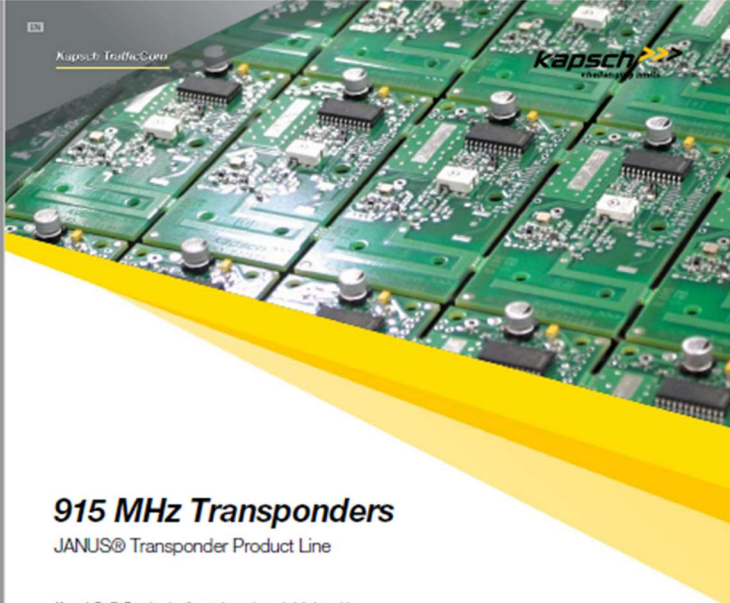
Kapsch offers a very unique exclusive mounting bracket specifically designed to install the MP14.1 with minimal effort. Install the bracket to almost any vertical or horizontal gantry/pole. Connect all cables to the reader in the safety of your bucket or on the ground and then simply hook the reader to the bracket and continue routing the cables. When ready, bolt the reader to the bracket. Kapsch also offers laminated cable assemblies to ease the installation process.

* The product contains technology licensed from Amtech Systems LLC. A list of these patents can be found at www.kapsch.com/comp/amer
Content subject to change without notice.

Kapsch TrafficCom North America: 2855 Promena Parkway, Suite F | Duluth, GA 30097 | USA | kic.na@kapsch.net
www.kicsales.net/components | www.kapschtraffic.com | Doc No.: Kapsch-KTC-DS-Janus-MP14.1-112023_EN

**Kapsch TrafficCom Report of Laboratory Testing and Impact Analysis for Kapsch NM-LMS Product against Interference from
NextNav Proposed Usage of the LMS Spectrum**

A.3. Transponders Data Sheet



915 MHz Transponders
JANUS® Transponder Product Line

Kapsch TrafficCom is a leading and experienced global provider of high-performance intelligent transportation systems. With its end-to-end portfolio, Kapsch offers solutions across its customer's entire value chain – from single products and components, to fully integrated turnkey systems and solutions in the applications of electronic toll collection, commercial vehicle operations and highway traffic management. Kapsch 915 MHz products and components offer an open, modular and flexible design, allowing our customers to meet individual market demand.

JANUS transponders and readers are designed for high performance in both lane-based and all-electronic toll collection environments, allowing agencies to select from a diverse array of implementation options.

Since 1993, Kapsch has provided this tried and true technology to agencies throughout North America. In April 2012, Kapsch released the TDM protocol which enables any manufacturer to produce TDM based transponders and readers with royalty-free license. This unprecedented support for nationwide tolling interoperability continues to demonstrate why Kapsch is the worldwide leader in all-electronic toll collection systems. In 2016, Kapsch introduced ISO 18000-63 (EPC) RFID transponders to the North American market to offer customers a choice of protocols that would meet national interoperability.



Doc No.: Kapsch-KTC-NAM_915_Transponder_Line-1 0202_01

Kapsch TrafficCom Report of Laboratory Testing and Impact Analysis for Kapsch NM-LMS Product against Interference from NextNav Proposed Usage of the LMS Spectrum

JANUS Transponder Product Line

JANUS transponders are available in several form factors including both interior and exterior options, all designed to accommodate many functional and installation requirements. JANUS transponders are easy to install, can be moved in-between vehicles, and can be provided complete with retail packaging designed specifically for each agency. Kapsch has a number of optional services to make the packaging and shipment of transponders easier for our customers.

Technical Specifications

Operating frequency

915.75 MHz nominal Rx center frequency
915 MHz nominal Tx center frequency

Data format

Manchester Keyed Carrier

Data rate

500kbps $\pm$ 10% (uplink/downlink)

Error Checking

16-bit Cyclic Redundancy Check (CRC)

Regulatory

FCC Part 90 and Part 15, Industry Canada RSS-137

Data Capacity

TDM Transponders:

- 256 bits (including control bits for driver feedback and current state and history for HOTPass®)

TDMAu6 Transponders:

- 512 bits (including control bits for feedback)
- Enhanced features: Battery monitoring, ID encryption

Kapsch TDM Transponders



Interior (TDM) Removable.

Dimensions

• 3.7 x 1.9 x 0.9 in. / 94.0 x 48.3 x 23.0 mm

Weight

• 0.116 lbs. / 52.6 g.



Exterior (TDM) License Plate, Bumper, Roof Mount.

Dimensions

• 8.4 x 1.8 x 1.1 in. / 213.4 x 45.7 x 27.9 mm

Weight

• 0.231 lbs. / 104.6 g.

Kapsch TrafficCom Report of Laboratory Testing and Impact Analysis for Kapsch NM-LMS Product against Interference from
NextNav Proposed Usage of the LMS Spectrum

Kapsch TDM & TDMAv6 Transponders

Kapsch TDM

Interior Driver Feedback
Removable

Dimensions
• 3.7 x 1.9 x 0.9 in. / 94.0 x 48.3 x 23.0 mm

Weight
• 0.118 lbs. / 53.4 g.

Kapsch TDMAv6

Interior Driver Feedback
Removable

Dimensions
• 3.6 x 2.8 x 1.0 in. / 90.6 x 70.9 x 25.7 mm

Weight
• 0.198 lbs. / 88.8 g.

Kapsch TDMAv6

Interior Switchable HOTPass® (High-Occupancy)
Removable

Dimensions
• 4.0 x 2.7 x 1.0 in. / 101.6 x 68.6 x 25.4 mm

Weight
• 0.187 lbs. / 84.8 g.

Kapsch TDMAv6

Interior Commercial Vehicle (CVO) By-Pass
Removable
Available without battery self-test button

Dimensions
• 4.0 x 2.6 x 0.9 in. / 101.6 x 66.0 x 23.6 mm

Weight
• 0.195 lbs. / 88.3 g.

Kapsch TrafficCom Report of Laboratory Testing and Impact Analysis for Kapsch NM-LMS Product against Interference from
NextNav Proposed Usage of the LMS Spectrum

Kapsch ISO 18000-63 (6C) Transponders

Kapsch 6C (RFID)*

**Interior 6C (RFID)
Permanent**

Dimensions
3.62 x 1.02 x 0.01 in. / 92.0 x 26.0 x 0.25 mm

Weight
0.005 lbs. / 2.2 g. (incl. removable label)



**Exterior 6C (RFID)
Permanent**

Dimensions
3.54 x 0.47 x 0.01 in. / 90.0 x 12.0 x 0.25 mm

Weight
0.002 lbs. / 1.7 g. (incl. bulky label & removable label)



**Interior Switchable 6C (RFID)
Removable, 2 or 3-position**

Dimensions
4.0 x 1.0 x 0.5 in. / 102 x 25.4 x 11.7 mm

Weight
0.038 lbs. / 17.2 g.



"Whatever the future might bring, Kapsch TrafficCom is always one step ahead in the right direction with products and solutions. Taking advantage of the newest technologies in practical applications is an integral part of the company strategy. Kapsch is committed to consistent value creation and technical excellence in our solutions for the real world needs of our customers."

J.B. Kendrick
President Kapsch TrafficCom North America

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20544**

<i>In the Matter of</i>	)	
	)	
Enabling Next-Generation Terrestrial	)	WT Docket No. 24-240
Positioning, Navigation and Timing and 5G:	)	
A Plan for the Lower 900 MHz Band (902-	)	
928 MHz)	)	

**KAPSCH TRAFFICOM TEST AND COEXISTENCE ANALYSIS OF KAPSCH NM-
LMS EQUIPMENT TO THE NEXTNAV PROPOSED WIRELESS
COMMUNICATIONS IN THE LMS BAND**

Alastair Malarky
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March 18, 2026

Kapsch TrafficCom (“Kapsch”) respectfully submits the attached test and coexistence analysis report in response to submissions filed by NextNav Inc. (“NextNav”) under the Wireless Telecommunications Bureau (WTB) Docket No. 24-240.

Kapsch is one of the world's most highly regarded providers of tolling, traffic management, smart urban mobility, traffic safety and security, and connected vehicles. The products and solutions of Kapsch cover the entire spectrum of toll collection services – from multi-lane free flow traffic on roads and highways, to traditional toll booths and managed lanes, and, specifically relevant to the petition, readers and transponders operating in the non-Multilateration Land Mobile Service (NM-LMS) sub-bands and support to the tolling operators with the roll-out and commercial operation of the systems. Kapsch toll customers are located throughout North America, and include the E-ZPass Group¹, other members of the International Bridge, Tunnel and Turnpike Association (IBTTA)², members of the 6C Coalition³, and members of the RAIN Alliance⁴.

Kapsch and other NM-LMS equipment vendors, and their customers, who use this band for non-Multilateration (NM-LMS) applications, both licensed and unlicensed, have significant concerns about the impact that 5G wireless communication networks deployed under the

¹ E-ZPass refers to the Interagency Group consisting of member toll agencies/companies in 20 states which operate ETC systems used on toll roads, toll bridges, and toll tunnels in the eastern half of the United States, and other applications using the same ETC equipment.

² The IBTTA is a worldwide alliance of toll facility operators and associated industries.

³ The 6C Coalition is a collaborative organization composed of toll facility operators/owners that use the International Organization for Standardization (“ISO”) 18000-63 (commonly known as “6C”) transponders as a primary method for automatic vehicle identification for the purpose of toll revenue collection.

⁴ The RAIN Alliance is RAIN Alliance Inc. is a U.S.-based, global non-profit organization, representing over 150 corporate members that develop and deploy RAIN RFID technology solutions addressing applications across many vertical markets. RAIN RFID (also known as passive UHF RFID and as “6C”) is a wireless technology that enables businesses and consumers to identify, locate, authenticate, and engage billions of items connected to the Internet of Things.

proposed rules will have on Electronic Toll Collection (ETC) and Commercial Vehicle Operations (CVO) including commercial vehicle pre-clearance e.g. at weigh stations.

NextNav has repeatedly affirmed that, “[f]or all types of licensed non-M-LMS systems, NextNav is committed to working with incumbent operators to develop coexistence solutions.”⁵ yet, while the NM-LMS vendors supported E-ZPass in attempting to establish a joint analysis and test plan with NextNav to develop such coexistence solutions, agreement was not reached with NextNav. Instead NextNav left the discussions and later submitted their own co-existence study⁶ on the proposed 5G wireless communications impact to ETC operations that is deemed inadequate and conclusions flawed and comments to that effect were filed by E-ZPass and IBTTA⁷, and subsequently Neology⁸. While NextNav has recently filed a response to these comments⁹ there are additional technical inadequacies and errors with their response. Thus, at this time no coexistence solutions have been agreed to between the parties.

The ability to co-exist depends on physical separation, RF geometries and characteristics including frequency susceptibility between the equipment that must co-exist. A necessary step in co-existence determination is the assessment of the level of risk and separation requirements. While NextNav continues to mis-represent the position of the ETC and CVO community as

⁵ Page 2, NextNav correspondence to FCC Secretary under docket 24-240, filed August 1 2025, with attachment “*Licensed Tolling Coexistence Study*”.

⁶ NextNav correspondence to FCC Secretary under docket 24-240, filed August 1 2025, with attachment “*Licensed Tolling Coexistence Study*”.

⁷ E-ZPass & IBTTA correspondence to FCC Secretary under docket 24-240, filed December 5, 2025 with attachment “*NextNav’s 5G/Tolling Study: Deeply Flawed and Inadequate to Support NextNav Conclusion* “

⁸ Neology Inc. correspondence to FCC Secretary under docket 24-240, filed December 5, 2025 with attachment “*Technical Report: Coexistence Assessment Between 5G NR and Non-Multilateration LMS Highway Tolling Systems Under NextNav’s Proposed Lower 900 MHz Band Plan* “

⁹ NextNav correspondence to FCC Secretary under docket 24-240, filed January 15, 2026 with attachment “*Technical Response to Neology and IBTTA / E-ZPass December 2025 Technical Submissions*”

“*rhetorical*”¹⁰, the key technology vendors, in cooperation with E-ZPass and the IBTTA, have continued to develop the analysis and test plan abandoned by NextNav and are, or have completed conducting laboratory tests and coexistence analysis to provide the FCC with objective and rigorous test data and analysis that exposes the risks to ETC and CVO operations, by first properly evaluating the susceptibility of their current NM-LMS equipment to networks deployed under the proposed rules. The attached report “*Kapsch TrafficCom Report Of Laboratory Testing Of Kapsch NM-LMS Product Against Interference From NextNav Proposed Usage Of The LMS Spectrum*” covers the susceptibility testing by Kapsch in support of that objective, as well as performing coexistence analysis based on those test results, and identifying some additional concerns with the rules as proposed. In the attached report,

- Section 2.1 summarizes the test results measured on Kapsch NM-LMS equipment,
- Section 2.2 summarizes issues resulting with the revised frequency plan and limitation to 11 MHz sub-band,
- Section 2.3 summarizes the Kapsch coexistence analysis findings for its equipment,
- Section 2.4 summarizes further issues identified in the rules as proposed, and
- Section 2.5 summarizes further issues or clarifications of issues previously identified in NextNav submissions.

Kapsch also observes that the operation in toll sites is not easily modelled due to the multitude of variables affecting the signals levels in the toll system, e.g. the high variability of

¹⁰ Page 4 of NextNav correspondence to FCC Secretary under docket 24-240, filed August 1 2025, with attachment “*Licensed Tolling Coexistence Study*”.

transponder performance on vehicles, and that proper coexistence analysis can only be carried out with field testing in real-world environments.

In contrast, while NextNav claims it is committed to “*transparency and rigorous, fact-based engineering analysis*”,¹¹ their reports present data on a very limited set of NM-LMS tolling equipment, and yet they generalize this data to be representative of all NM-LMS equipment. Note that the DEKRA North America laboratory¹² which NextNav contracted to perform the measurements has in its possession tolling equipment from most of the toll vendors, and in particular Kapsch transponders and readers, whose susceptibilities are reported in the attached, and which are in many cases markedly different from the results used by NextNav to draw its coexistence conclusions.

NextNav’s continued extrapolation of measurements of a small subset of NM-LMS equipment to be representative of all equipment is exacerbated in the recent submission¹³ where the antenna patterns they had measured on transponders are erroneous and not representative of transponders used in ETC or CVO, despite NextNav having been informed in the E-ZPass discussions that “*(NM-)LMS Tags are simple devices. Normally dipole antenna in free space. Some tags have some directionality*”. This erroneous data is used to justify their arguments in their response; hardly a “rigorous” engineering analysis.

NextNav have also clearly stated they their tolling coexistence is based on a number of assumptions¹⁴, yet they then conclude their analysis of deployments based on those assumptions

¹¹ Page 3 of NextNav correspondence to FCC Secretary under docket 24-240, filed August 1 2025, with attachment “*Licensed Tolling Coexistence Study*”.

¹² Page 3 of NextNav correspondence to FCC Secretary under docket 24-240, filed August 1 2025, with attachment “*Licensed Tolling Coexistence Study*”.

¹³ Antenna patterns in NextNav correspondence to FCC Secretary under docket 24-240, filed January 15, 2026 with attachment “*Technical Response to Neology and IBTTA / E-ZPass December 2025 Technical Submissions*”

¹⁴ Eg NextNav Tolling coexistence study, page 29

and the limited subset of test data to declare this is proof there is no potential for co-existence issues. The attached report proves that there are substantive risks for co-existence and without ETC equipment updates or replacements, coexistence is not possible .

NextNav¹⁵ has also stated that “*NextNav’s proposal to enable 5G-based positioning, navigation, and timing (“PNT”) in the Lower 900 MHz band would impose minimal costs related to licensed tolling operations, limited to potential retuning of a subset of tolling operators’ toll readers*”¹⁶ and repeatedly stated (emphasis added by Kapsch) “***To the extent that retuning of some toll readers is required, NextNav has committed to reasonable accommodations, including financial and technical support, that contribute to a smooth transition to an optimized Lower 900 MHz band plan***”. The stated limitation implies that NextNav does not understand the impacts and costs that implementation of its proposal will cause.

As identified in a separate submission¹⁷, it is not just a matter of retuning, and further as identified in the attached report there will need to be equipment replacements and redesigns to achieve coexistence, as well as some form of co-existence management to ensure the deployment of the proposed system does not cause interference to incumbent ETC and CVO services.

NextNav have also stated that the limitation of ETC and CVO to 11 MHz sub-band should not cause issues, yet the attached analysis indicates that >11 MHz for ETC operations is

¹⁵ NextNav correspondence to FCC Secretary under docket 24-240, filed August 1 2025, with attachment “Licensed Tolling Coexistence Study”.

¹⁶ NextNav correspondence to FCC Secretary under docket 24-240, filed August 1 2025, with attachment “Licensed Tolling Coexistence Study”, and

NextNav correspondence to FCC Secretary under docket 24-240, filed January 15, 2026 with attachment “Technical Response to Neology and IBTTA / E-ZPass December 2025 Technical Submissions”

¹⁷ Kapsch correspondence to FCC Secretary under docket 24-240, filed 19 February 2026 “Comments Of Kapsch TrafficCom In Regard To Certification Of NM-LMS Equipment To The NextNav Proposed Frequency Plan”

needed because of the guard bands that will be needed to mitigate the interference from the proposed system.

In addition to the certification issues identified in the previous Kapsch submission¹⁸, the attached test report indicates current Kapsch readers have significant susceptibility to the proposed 5G downlink signals that requires significant separation distances for coexistence risk mitigation and/or product modification or replacement.

Further NextNav has failed to provide any reasonable evidence there will not be a reciprocal co-existence problem between incumbent users of the NM-LMS spectrum and the proposed wireless broadband service and to the positioning and timing performance promised by NextNav. A fact-based rigorous engineering analysis would require that the co-existence risk be clearly analyzed in both directions and data presented in a transparent manner that allows the other parties to verify the information, which would have been the case had NextNav continued the joint analysis and test plan with E-ZPass. To date NextNav has not provided any evidence that this reciprocal coexistence has been analyzed, and the arguments in their response¹⁹ stating there is no issue with susceptibility to out of band emissions because existing 5G systems out of band emissions do not cause issues is clearly a rhetorical argument which omits basic physics like the difference in physical separations, geometry and antenna directivity when considering toll system interference to 5G systems compared to interference between 5G systems.

Further the clear volume of to-and-fro of comments suggests a clear technical definition is required for the proposed 5G system, including but not limited to proposed reference cell

¹⁸ Kapsch correspondence to FCC Secretary under docket 24-240, filed 19 February 2026 “Comments Of Kapsch TrafficCom In Regard To Certification Of NM-LMS Equipment To The NextNav Proposed Frequency Plan”

¹⁹ NextNav correspondence to FCC Secretary under docket 24-240, filed January 15, 2026 with attachment “Technical Response to Neology and IBTTA / E-ZPass December 2025 Technical Submissions”

radius, link budgets and other parameters, both for the wireless broadband service and for the positioning and timing service, which if NextNav had provided would have avoided much of the commentary.

In conclusion, Kapsch believes there is sufficient evidence that coexistence risk exists for ETC and CVO based on the NextNav proposal and based upon the data provided in this test report and the multitude of other responses to Docket No. 24-240, the FCC should reject at this time a call to issue a NPRM.



June 3, 2026

The Honorable Brett Guthrie
Chairman
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Frank Pallone, Jr.
Ranking Member
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Richard Hudson
Chairman
Subcommittee on Communications and
Technology
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Doris Matsui
Ranking Member
Subcommittee on Communications and
Technology
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

Re: C&T Subcommittee hearing entitled “Where Are We?: Examining Positioning, Navigation, and Timing Capabilities in the United States”

Dear Chairman Guthrie, Ranking Member Pallone, Chairman Hudson, and Ranking Member Matsui:

On behalf of Iridium Communications Inc. (“Iridium”), thank you for holding this important hearing that focuses on positioning, navigation, and timing (“PNT”) systems, which are mission-critical to both the U.S. public and private sectors. This hearing presents an important opportunity to underscore the need for a market-driven, technology-neutral ecosystem of complementary and alternative commercial PNT solutions.

For decades, Iridium has been a leading American company providing mobile-satellite service (“MSS”) communications, serving more than 2.5 million subscribers worldwide. Iridium is also a major provider of satellite communications to the federal government, principally serving the Department of War and delivering mobile satellite products and services to agencies and offices across the government for a wide range of applications. Directly and indirectly, the U.S. government is Iridium’s largest customer.

As I stated in my April testimony when I had the privilege of testifying before this Subcommittee on the *SAT Streamlining Act*, Iridium offers the first truly global low-Earth orbit (“LEO”) PNT solution, [Iridium PNT](#) (formerly known as STL), providing resilience with exceptional reliability, high security, and robust signal strength, including indoors. Iridium

PNT thus complements GPS with a stronger, secure signal that works everywhere, even when GPS or other Global Navigation Satellite Systems (“GNSS”) are disrupted or unavailable.

Iridium PNT is one of the few commercial PNT services available today and the only commercial satellite-based alternative PNT service currently in operation. Iridium PNT provides an additional high-performance, resilient, and reliable source of timing and location synchronization for a wide range of critical infrastructure applications, including 5G networks, data centers, transportation, and financial services. Iridium PNT is delivered through the Iridium® LEO satellite constellation, which efficiently routes traffic through a satellite network architecture of 66 non-geostationary orbit satellites, in-orbit spares and related ground infrastructure.

Solutions such as Iridium PNT offer a redundant alternative to GNSS for global timing and location services without many of its vulnerabilities. Like GNSS, Iridium PNT provides worldwide coverage, but it is less susceptible to signal interception and disruption. It uses cryptographic techniques and a rapidly moving, smaller satellite footprint with highly complex, overlapping beam patterns, making its signals far more difficult to hack or spoof than non-cryptographically secured GNSS signals transmitted from distant satellite constellations. Iridium PNT also operates globally, providing equally reliable PNT solutions in urban, suburban, rural, and remote environments, and its LEO-based architecture allows signals to propagate indoors due to satellites being 25 times closer to earth than GNSS MEO satellites, with signals that are 30 db stronger than GNSS.

The U.S. Government has recognized Iridium PNT as an effective GPS alternative for precise timing. Iridium has a cooperative agreement with the National Institute of Standards and Technology (“NIST”) that directly links its operational infrastructure to NIST’s source of Coordinated Universal Time (“UTC”), the U.S. national standard for time and frequency maintained in coordination with the U.S. Naval Observatory. NIST found that “STL is a reliable source of timing that’s highly consistent with UTC(NIST) and is based on a signal that’s resilient to regional GPS outages.” Tests conducted in 2023 over several months at Iridium and NIST facilities likewise showed that “STL timing receivers, utilizing only signals originating from a LEO satellite constellation, provide a globally available time reference that’s a viable backup or alternative to GPS.”

Drawing on our experience as a company currently operating a commercially available alternative PNT service, Iridium respectfully submits three guiding principles for the Subcommittee’s consideration to help support the industry’s continued growth and resilience:

- 1. Take a Market-Driven Approach to Commercial PNT:** The commercial PNT sector is thriving, and the U.S. Government should avoid interfering with ongoing developments that could harm the commercial sector. There are numerous other alternative or complementary PNT solutions in varying stages of development and deployment, demonstrating both the demand and promise of this technology. Congress and the Federal Communications Commission (“FCC”) should avoid taking any action that would result in it picking *de facto* winners and losers among commercial PNT solutions.
- 2. There Is No One-Size-Fits-All PNT Solution:** Congress should continue to recognize, as this Subcommittee has before, that a technology-neutral approach is essential because different technologies, whether terrestrial or space-based, are better suited to different PNT functions and use cases. Additionally, different PNT solutions are susceptible to different vulnerabilities depending on the technology, which is further reason to encourage PNT source and technology diversity as a secure-by-design principle that ensures redundant and resilient systems across a range of technologies. Considering that timing and location errors can be particularly problematic for public safety, defense, and critical infrastructure, reliance exclusively on GPS or only a single alternative PNT source would undermine American security and resiliency. All commercial PNT solutions should demonstrate technological readiness, independent third-party validation, security best practices, and coexistence with other operators before being approved and deployed, as exemplified by Iridium PNT.
- 3. Promote an All-of-Government Approach to Commercial PNT Solutions:** The Trump Administration and multiple federal agencies have already taken important steps to advance resilient PNT, including alternative PNT solutions. The White House, NIST, the National Telecommunications and Information Administration, and the U.S. Department of Homeland Security have each recognized the importance of greater diversity in PNT sources to strengthen critical infrastructure resilience. Congress and the FCC can build on that strong foundation by supporting a coordinated, government-wide approach to commercial PNT. Clear and consistent federal leadership on the value of multiple alternative PNT sources using diverse technologies will help drive continued innovation and broader adoption.

Iridium supports policies that encourage innovation in alternative PNT solutions and help bring new technologies to market while strengthening resilience and redundancy. Private-sector innovation in PNT, such as Iridium PNT, is already strengthening the resilience and

security of critical infrastructure and other PNT-dependent applications. By maintaining a holistic, market-driven approach, Congress and the Trump Administration can help ensure that these commercial PNT alternatives continue to develop and contribute to the nation's economic and national security interests.

Thank you for your consideration. Iridium looks forward to working with the Subcommittee on these important issues moving forward.

Sincerely,

Kara Leibin Azocar
Vice President, Regulatory & Public Policy
Iridium Communications Inc.
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McLean, VA 22102
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June 3, 2026

The Honorable Brett Guthrie
Chairman
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Frank Pallone
Ranking Member
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

Dear Chairman Guthrie and Ranking Member Pallone,

On behalf of the more than 366,000 members of the International Association of Fire Fighters, thank you for convening the upcoming hearing to examine issues related to global positioning systems (GPS). As the Committee examines this issue, I urge you to support proposals that would improve fire fighter safety by more accurately tracking their locations within buildings. When fire fighters enter buildings to rescue victims or suppress fires, we must have the tools to track their locations and ensure they safely exit the buildings. Too many fire fighters have been lost in buildings to allow this problem to continue.

One of the most dangerous tasks a fire fighter can perform is entering a burning building to rescue trapped victims. Smoke and fire conditions can easily cause a fire fighter to become disoriented and trapped in a building. Countless fire fighters have been lost while fighting fires in abandoned factories, warehouses, and other large buildings with few windows or visual landmarks. As part of this problem, fire fighters also need technologies that can track their height within a building rather than only their longitude and latitude. The threat of losing fire fighters in buildings is becoming increasingly acute as data centers emerge in communities nationwide. We cannot allow fire fighters' dangerous jobs to be even more dangerous by delaying investigations into critical safety technologies.

The IAFF urges both Congress and the Federal Communications Commission (FCC) to prioritize their work to assess how advancing location technologies can address this safety issue facing fire fighters. As the FCC completes this work, we also urge the FCC to work closely with national fire service stakeholder organizations to review the performance of these systems. The direct assessment and feedback of fire fighters is needed to ensure any proposed solution to fire fighter location tracking is both reliable and accurate.

Furthermore, the development of improved and redundant location-tracking technology is important for helping fire fighters locate 9-1-1 callers during emergencies and efficiently find emergency incident locations during GPS outages. As GPS jamming technologies become more accessible and the threat of terrorist attacks remains high, fire fighters must have redundancies in their ability to locate and respond to emergencies quickly.

Thank you again for your work to ensure access to reliable and redundant location technology. These technologies are not only critical to commerce and daily life but also play an important role in helping fire fighters perform their work effectively and safely. I urge you to continue working closely with national fire service stakeholders to ensure fire fighters have the tools they need to protect our communities and return home after every shift.

Sincerely,

A handwritten signature in blue ink that reads "Edward A. Kelly". The signature is fluid and cursive, with the first name "Edward" and last name "Kelly" clearly legible.

Edward A. Kelly
General President

Statement for the Record

Submitted to the House Committee on Energy & Commerce Subcommittee on Communications
& Technology

For the Hearing “*Where Are We?: Examining Positioning, Navigation, and Timing Capabilities
in the United States*”

Thursday, June 4, 2026

Overview

Chairman Hudson, Ranking Member Matsui, Chairman Guthrie, Ranking Member Pallone and Members of the Committee:

On behalf of the Edison Electric Institute (EEI) and the nation’s investor-owned electric companies, thank you for the opportunity to submit testimony on the importance of resilient positioning, navigation, and timing (PNT) capabilities.

EEI’s member companies provide electricity to more than 250 million Americans and operate critical infrastructure that underpins our economy, national security, and public safety. EEI’s members are among the nation’s largest users of communications services and operate extensive private communications networks in the nation. These investments are essential to strengthening the grid’s reliability, security, and resilience.

Accordingly, EEI and its members have a strong interest in ensuring that electric companies have the communications capabilities necessary to meet their obligation to deliver safe, reliable, resilient, and cost-effective power.

America’s electric companies strongly support efforts to strengthen GPS resilience and develop reliable backup PNT solutions. These capabilities are critical to national security and modern infrastructure.

At the same time, the Federal Communications Commission (FCC) is considering a proposal by NextNav to significantly restructure the 902-928 MHz (Lower 900 MHz) band. While presented as a PNT initiative, the proposal would introduce high-power, wide-area wireless transmissions into a band that today supports low-power communications used for grid operations.

Fundamentally, this is not simply a spectrum management decision, it is a grid reliability and resilience issue because it would unintentionally weaken the communications systems utilities depend upon to operate the electric grid.

Why the Lower 900 MHz Band Matters for Grid Operations

For decades, electric, gas, and water utilities have relied on the Lower 900 MHz band to support essential communications systems under established FCC rules. Electric companies use this band to detect outages in real time, isolate faults and prevent cascading disruptions, restore service

quickly after storms, monitor wildfire conditions and protect public safety, as well as maintain visibility into increasingly complex grid infrastructure.

These systems are widely deployed across urban and rural America and are deeply integrated into how utilities operate the grid and build for reliability over decades-long lifecycles. Their performance is especially critical in rural areas, mountainous terrain, underground infrastructure, wildfire-prone regions, and during severe weather events, when other networks may be unavailable.

What the NextNav Proposal Would Change

The NextNav proposal would fundamentally change how this band operates by:

- Creating a nationwide 15 MHz licensed block.
- Introducing significantly higher power transmissions across wide areas.
- Enabling commercial broadband/5G uses alongside PNT.
- Reducing spectrum available for existing users.
- Moving away from a predictable rules-based framework toward a model that could impose new constraints or coordination requirements incumbent users.

In practical terms, this would shift the band from a shared environment supporting many critical uses into one increasingly dominated by a new, high-power network.

The Risk: Degrading Reliability When It Matters Most

The central concern is not sudden system failure, but rather a gradual loss of reliability of the communications systems that support grid operations. This can result in slower detection of outages, reduced situational awareness during emergencies, delays in restoring service, and greater reliance on manual processes that do not scale.

Critically, these effects are system-wide, not isolated, difficult to detect in advance, and most likely to occur during events like hurricanes, wildfires, or extreme weather. In short, the risk is degraded performances when the grid is needed the most.

Scale of Impact

The systems at issue are widely deployed and deeply integrated. Preliminary data from major utilities show:

- 50+ million electric and gas AMI meters depend on this band.
- 450,000+ SCADA, DA, and field devices are at risk.
- 160–200 million utility devices nationwide could be affected.
- 100% of smart meters in the band would be impacted.
- Many assets are mid-life or early-life, creating major stranded investment risk.
- Some utilities face up to \$4 billion in replacement costs.
- National cost exposure exceeds \$100 billion.

Importantly, these costs would ultimately fall on customers and divert capital from grid hardening, wildfire mitigation, transmission expansion, and infrastructure upgrades needed to support new load growth, including AI and data centers

Utilities cannot simply “switch bands.” Replacement timelines span **10–15 years**, and many utilities no longer have the staffing to revert to manual operations at scale.

GPS Resilience Should Not Come at the Expense of Critical Infrastructure Resilience

Electric reliability affects public safety during extreme weather, economic activity and business continuity, national security, and critical infrastructure, as well as the ability to support emerging demands like data centers and advanced manufacturing. Even modest degradations in grid performance can translate into longer outages, slower recovery times, and higher costs for customers.

Electric companies support the goal of strengthening national PNT capabilities. However, a core principle should guide policy decisions: Efforts to improve resilience in one system should not introduce new vulnerabilities in another. The proposal, as currently structured, risks doing exactly that, potentially improving PNT objectives while undermining the communications foundation of the electric grid.

Conclusion

The electric grid is the backbone of our economy and national security. The communications systems that support grid operations are equally essential, especially in times of crisis.

Any change that introduces risk into that communications layer of the electric grid must be evaluated with the highest level of care.

EEI respectfully urges policymakers to:

1. Maintain enforceable interference protections for incumbent utility systems.
2. Prevent stranded investment in mission-critical infrastructure.
3. Avoid large-scale cost shifts to electricity customers.
4. Ensure PNT initiatives do not undermine grid reliability or public safety.
5. Develop a transparent, utility-validated evidentiary record before taking any action that would authorize higher-power operations in the band.

EEI appreciates the Committee’s leadership and stands ready to work with Congress, the FCC, the Department of Energy, and other stakeholders to strengthen national resilience while protecting the reliability of the electric grid.

June 3, 2026

The Honorable Brett Guthrie
Chairman
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Frank Pallone, Jr.
Ranking Member
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Richard Hudson
Chairman
Communications and Technology
Subcommittee
U.S. House of Representatives
Washington, DC 20515

The Honorable Doris Matsui
Ranking Member
Communications and Technology
Subcommittee
U.S. House of Representatives
Washington, DC 20515

Dear Chairman Guthrie, Ranking Member Pallone, Subcommittee Chairman Hudson, and Subcommittee Ranking Member Matsui:

The undersigned entities applaud this Committee's commitment to supporting complementary Positioning, Navigation, and Timing ("PNT") solutions to augment the Global Positioning System ("GPS"). Advancing PNT resiliency is critical for the nation's economic prosperity, technological leadership, and national security.

Today, a whole-of-government effort is underway: the U.S. Department of Transportation is engaged in a critical assessment evaluating the efficacy of more than a dozen complementary PNT services;¹ the Federal Communications Commission ("FCC") has launched a comprehensive inquiry that generated a fulsome record of technological solutions and alternatives;² and the National Telecommunications and Information Administration ("NTIA") has identified approximately 50 potential technologies or solutions that could complement GPS.³ A multitude of space-based, terrestrial, and non-spectrum-dependent solutions exist to bolster the nation's PNT infrastructure.

We write to express our ongoing opposition to one proposed alternative: NextNav, Inc. ("NextNav") and its reconfiguration of the 902-928 MHz ("Lower 900 MHz") spectrum

¹ Press Release, DoT, *Department of Transportation Awards \$7 million for Complementary Positioning, Navigation and Timing Technologies* (July 3, 2024), <https://www.transportation.gov/briefing-room/department-transportation-awards-7-million-complementary-positioning-navigation-and>; SAM.gov, *Complementary Positioning, Navigation, and Timing (CPNT) Services Rapid Phase II*, Award Notices, <https://sam.gov/opp/396f1f1e901a4155ace2263e3c70a588/view>.

² *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, Notice of Inquiry, WT Docket No. 25-110, FCC 25-20 (Mar. 28, 2025).

³ *Ex Parte* Letter from David Brodian, Chief Counsel, NTIA to Marlene H. Dortch, Secretary, FCC, WT Docket No. 25-110 (May 27, 2025), <https://www.fcc.gov/ecfs/document/1052783551421/1>.

band, a workhorse spectrum band for American innovation and technology. The NextNav proposal threatens interference to billions of devices that American consumers and U.S. companies and innovators rely on every day, requiring hundreds of billions of dollars to replace equipment and operations. NextNav would disrupt the Lower 900 MHz band to lease the vast majority of its spectrum capacity to mobile network operators for 5G wireless services, while using a small portion of its licenses for a 5G-based PNT backup system.⁴

In multiple rounds of FCC comments, hundreds of stakeholders representing current users of the band in the public safety, tolling, transportation, critical infrastructure, and supply chain logistics communities (among others), have explained the serious technical, economic, legal, and regulatory problems NextNav's spectrum monetization scheme would generate. We attach here some of the key filings in the exhaustive and nearly unanimous FCC record opposing NextNav's proposal:

- [Lower 900 MHz Band Users](#). Filing by the Connected Devices for America Coalition, E-ZPass Group, International Bridge, Tunnel, and Turnpike Association ("IBTTA"), American Trucking Associations ("ATA") and 21 state trucking associations, Connectivity Standards Alliance, LoRa Alliance, National Retail Federation ("NRF"), RAIN Alliance Inc., Retail Industry Leaders Association ("RILA"), Wi-Fi Alliance, and WISPA – The Association for Broadband Without Boundaries, explaining that it is time for the FCC to close out the chapter on NextNav, and raising a series of questions about the NextNav proposal's commercial viability, NextNav's inability to address the interference issues that would affect existing users of the Lower 900 MHz band (and proposed 5G users), the economic impacts of NextNav's proposal on incumbent operations, and the implications of NextNav's proposal for U.S. national security, federal users, and critical public safety operations.
- [Public Safety](#). Filing by the International Association of Fire Chiefs ("IAFC"), the International Association of Chiefs of Police ("IACP"), the Association of Public-Safety Communications Officials-International ("APCO"), and the National Sheriffs' Association ("NSA") explaining that NextNav's proposal would negatively affect existing operations that rely on Lower 900 MHz spectrum and are essential to the preservation of life and safety, such as man-down systems, self-contained breathing apparatus ("SCBA") systems, and automatic utility gas/electric shut off capabilities, among others.
- [Tolling](#). Filing by 44 tolling agencies and operators in 22 States, explaining that NextNav's proposal risks disrupting the electronic tolling systems that millions of Americans rely on, leading to more traffic congestion, backup, and delays,

⁴ See Petition for Rulemaking of NextNav Inc., WT Docket No. 24-240 (filed Apr. 16, 2024) (as supplemented by Letter from Robert Lantz, General Counsel, NextNav Inc., to Marlene H. Dortch, Secretary, FCC, WT Docket No. 24-240 (filed June 7, 2024)).

resulting in replacement costs and economic loss of at least \$6.8 billion, and causing billing errors that endanger toll revenues that play an essential role in state and local budgets for U.S. infrastructure.

- [Critical Infrastructure](#). Filing from ecobee, Itron, and Landis+Gyr estimating that NextNav's proposal would cost utilities and ratepayers upwards of \$100 billion in direct expenses for workarounds and equipment replacement, plus incalculable indirect costs from lost electrical, water, and gas utility efficiencies and expenses—all at a time when grid capacity and consumer affordability have never been more critical.
- [RFID](#). Filing from RAIN Alliance submitting an economic study estimating costs of between \$5 to \$7.2 billion to RAIN RFID end users of replacing or retrofitting equipment, in addition to indirect costs such as transition and disruption costs, innovation chilling effects, and loss of consumer welfare.
- [Pericle Study](#). Filing from the Security Industry Association submitting a technical coexistence study conducted by Pericle Communications Company, showing that NextNav's proposal would cause intolerable interference to existing unlicensed Lower 900 MHz band users, and the proposed NextNav network would, in turn, experience intolerable amounts of interference from existing Part 15 devices, thereby forcing incumbent users to shut down operations in the band.

This Committee, and the U.S. government as a whole, should advance its critical work on complementary PNT systems without the distraction of the NextNav proposal, which would disrupt public safety and other government operations, increase prices for consumers, and harm American businesses.

Please feel free to contact us if you have any questions or need more information.

Regards,

/s/ Avi Rosenthal

Avi Rosenthal
Chair
**Connected Devices for
America Coalition**

/s/ PJ Wilkins

PJ Wilkins
Executive Director
E-ZPass Group

/s/ Kevin Grove

Kevin Grove
Director, Safety &
Technology Policy
**American Trucking
Associations (ATA)**

/s/ Olivier Beaujard

Olivier Beaujard
Chair
LoRa Alliance

/s/ Aileen Ryan

Aileen Ryan
President & CEO
RAIN Alliance Inc.

/s/ Alex Roytblat

Alex Roytblat
Vice President Worldwide
Regulatory Affairs
Wi-Fi Alliance

/s/ Louis Peraertz

Louis Peraertz
Vice President of Policy
**WISPA – The Association
for Broadband Without
Boundaries**

/s/ Gustaf Lonaeus

Gustaf Lonaeus
Vice Chairman
Z-Wave Alliance

Attachments:

Joint Opposition Letter from Lower 900 MHz Band Users
Public Safety Opposition Letter
Tolling Opposition Letter
Critical Infrastructure Opposition & Economic Harms Letter
RFID Opposition & Economic Harms Letter
Pericle Technical Study

March 26, 2026

Via ECFS

Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street, NE
Washington, DC 20554

RE: ***Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions (WT Docket No. 25-110); Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking (WT Docket No. 24-240)***

Ms. Dortch,

The undersigned entities support the U.S. government’s commitment to launching complementary Positioning, Navigation, and Timing (“PNT”) to augment the Global Positioning System (“GPS”). As Federal Communications Commission (“FCC”) Chairman Carr recently observed, GPS “is a single point of failure,” and it is critical to consider a range of different ways to stand up alternatives, or compliments, to GPS.¹ The record in response to the FCC’s 2025 *Notice of Inquiry* showcased multiple technologies (space-based, terrestrial-based, and non-spectrum-dependent) for governmental and commercial stakeholders to consider.² This work is part of a whole-of-government effort—the U.S. Department of Transportation, for example, is engaged in a critical assessment evaluating the efficacy of more than a dozen complementary PNT services.³

¹ Statement of Brendan Carr, Chairman, FCC, at 3:06:04, *Oversight of the Federal Communications Commission: Hearing Before the Subcomm. on Communications and Technology of the H. Comm. on Energy and Commerce* (YouTube Jan. 14, 2026).

² See *Promoting the Development of PNT Technologies and Solutions*, Notice of Inquiry, 40 FCC Rcd 2641 (2025) (“NOI”); *Ex Parte* Letter from NTIA to FCC, WT Docket No. 25-110 (May 27, 2025), <https://www.fcc.gov/ecfs/document/1052783551421/1> (noting that approximately 50 potential alternatives or complements to GPS are currently available or in development (including NextNav’s proposed solution)); see also Christopher Mims, *The World Is Full of GPS Dead Zones. Here’s What Comes Next*, Wall St. J. (Mar. 6, 2026) (noting that several “suitable alternatives [to GPS] . . . are already in use [] or are on the cusp of widespread commercialization”).

³ Press Release, DoT, *Department of Transportation Awards \$7 million for Complementary Positioning, Navigation and Timing Technologies* (July 3, 2024), <https://www.transportation.gov/briefing-room/department-transportation-awards-7-million-complementary-positioning-navigation-and>; SAM.gov, *Complementary Positioning, Navigation, and Timing (CPNT) Services Rapid Phase II, Award Notices*, <https://sam.gov/opp/396f1f1e901a4155ace2263e3c70a588/view>.

As the FCC appears to be nearing a notice of proposed rulemaking (“NPRM”) on PNT technologies and solutions,⁴ one thing is abundantly clear: it is time to close out the chapter on NextNav, Inc. (“NextNav”) and its spectrum monetization proposal that would upend the 902-928 MHz band (the “Lower 900 MHz Band”) to advance its limited, questionable PNT solution.⁵ Hundreds of stakeholders representing Lower 900 MHz Band licensees and unlicensed users of the band in the public safety, tolling, transportation, critical infrastructure, and supply chain logistics communities (among others), with concern for billions of devices operating in Lower 900 MHz Band spectrum across the U.S. today, have explained the serious technical, economic, legal, and regulatory problems NextNav’s proposal would create. The record has also exposed the limitations inherent in the NextNav plan.

After four rounds of public comment dominated by opposition to NextNav,⁶ the FCC is no longer operating on a clean slate. With more than 18 months of engineering studies and economic analyses, near unanimous opposition persists, as NextNav has failed to demonstrate its solution can coexist with the billions of devices that operate in the Lower 900 MHz Band. An NPRM on complementary PNT systems should move forward without the distraction of the NextNav proposal, which would generate massive disruption to consumers, enterprises, and public safety and other government operations and render billions of dollars of equipment obsolete due to interference.

If the FCC determines that further comment on NextNav’s proposal is warranted, then the NPRM should build on the substantial record of evidence that already exists on the issue. It should incorporate specific questions on the following issues:

- NextNav’s proposed system, its effectiveness, threshold commercial matters necessary for its success, and the technical impacts that licensed toll equipment and other licensed and unlicensed users are expected to have on the commercial viability of the NextNav proposal;
- The technical impacts NextNav’s proposal would have on tolling and other licensed operations in the band;
- The technical impacts NextNav’s proposal would have on unlicensed operations in the band;
- The economic impacts of NextNav’s proposal on incumbent operations; and

⁴ The FCC has submitted a draft proposed rule to the Office of Management and Budget for federal interagency coordination. See Office of Management and Budget, Office of Information and Regulatory Affairs, *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, RIN 3060-AM01 (received Mar. 2, 2026).

⁵ NOI ¶ 29; see also Petition for Rulemaking of NextNav, Inc., WT Docket No. 24-240 (Apr. 16, 2024) (“NextNav Petition”).

⁶ The vast majority of commenters in both dockets, including an extraordinary number of incumbent users of the Lower 900 MHz Band, opposed NextNav’s proposed disruption of the band in comments and reply comments filed in the NextNav Petition for Rulemaking and the NOI proceedings.

- The implications of NextNav’s proposal for U.S. national security, federal users, and critical public safety operations.

1. NextNav’s Proposed Solution, its Effectiveness, and Threshold Commercial Matters Necessary for Its Success.

NextNav PNT and Proposed Geographic Coverage. NextNav proposes that the FCC revamp the Lower 900 MHz Band “in a manner that allows it to be used for 5G so that the [proposed] PNT network will be integrated within NextNav partners’ broadband networks.”⁷ The proposal also relies on a license “swap” in which NextNav would turn in active and inactive licenses totaling 14 megahertz that cover only certain portions of the country and receive instead a full nationwide, 15-megahertz license.⁸

- Given the critical importance of geographic coverage for any complementary GPS solution, what percentage of U.S. land mass would NextNav’s solution cover, based on its 5G partner’s (or partners’) terrestrial wireless infrastructure? This question is highly relevant as aggregate U.S. terrestrial wireless geographic coverage falls well short of full service coverage of U.S. land mass.⁹
- NextNav’s PNT solution is based on using 3GPP 5G Positioning Reference Signal (“PRS”) signals which, it asserts, “allows [its] solution to take advantage of the 3GPP standardized [New Radio] ecosystem” including commercial base stations and user equipment.¹⁰ The PRS DL-TDOA 3GPP standard option, that NextNav leverages,¹¹ requires signals from three 5G base stations, whereas commercial 5G deployments may not deliver such base station overlap, especially in non-urban areas.¹² To acquire sufficient PRS signals, will NextNav need to deploy infrastructure beyond that which its wireless partner deploys for its commercial deployments and if so, how much additional infrastructure would be required? Would the presence of such additional higher power transmitters increase interference levels due to proximity to lower power incumbent devices?
- Given that NextNav’s PNT solution requires less than five percent (5%) of its proposed licensed capacity,¹³ what benefit accrues from its request to expand its licensed holdings from 14 to 15 megahertz?
- Under what legal authority could the Commission implement NextNav’s proposal to exchange its portfolio of active and inactive licenses, which today does not include

⁷ NextNav Petition at iii.

⁸ *Id.* at 29-30.

⁹ According to data from the latest FCC Communications Marketplace Report, less than half of the U.S. land area was covered by at least one 5G-NR service provider at a minimum speed of 7/1 Mbps as of December 2023. 2024 Communications Marketplace Report, 39 FCC Rcd 14116, 14214 ¶ 128 (2024).

¹⁰ NextNav Petition, Exh. A at A-7.

¹¹ *Id.* at A-4 - A-7.

¹² Mark Sturza, 3C Systems Co., *NextNav, Local Terrestrial Complement, Not Legitimate GPS Backup*, Technical Report, at 3 (Feb. 6, 2026), <https://www.fcc.gov/ecfs/document/10209194826407/1>.

¹³ NextNav Petition at 27 (noting that “because 5G PRS uses only a small part of the 5G network’s capacity, at least 95% of the spectrum capacity will be available for additional services.”).

large portions of Texas, Michigan, Minnesota, and Wisconsin (and smaller portions of other states), for a full nationwide license, and increase its holdings from 14 to 15 megahertz?¹⁴

NextNav PNT Reliance on the Lower 900 MHz Band. The 3GPP PRS standard that NextNav relies upon is already available for 5G spectrum bands.¹⁵

- Is there anything unique about NextNav’s 5G-based PNT solution that would dictate deployment of NextNav’s proprietary solution over this specific set of frequencies?

NextNav PNT, Commercial 5G Demand for 15 megahertz in the Lower 900 MHz Band, and Necessary Wireless Device Ecosystem Upgrades. NextNav’s proposal is premised on partnering with 5G operators and “integrat[ing] NextNav’s Lower 900 MHz Band spectrum into their 5G networks.”¹⁶ In particular, NextNav would provide access to its proposed 15-megahertz license in the Lower 900 MHz Band – a 5 MHz x 10 MHz FDD license.

- What is the commercial 5G market demand for 15 megahertz (5 MHz x 10 MHz) of licensed, below-1-GHz spectrum access?
- Would commercial 5G network architecture revisions be required or does current commercial network synchronization and architecture satisfy complementary PNT needs?
- Is the Lower 900 MHz Band incorporated into 3GPP standards for macro-cellular, high-power 5G services (consistent with NextNav’s proposed band plan) or is that step required (and, if so, then what is the expected timeframe for completion)? What is the process and likelihood of 5G device manufacturers incorporating a Lower 900 MHz Band radio chipset into 5G devices?
- PNT capability and demand extends far beyond smartphones and other 5G mobile devices. How does NextNav intend to incorporate Lower 900 MHz Band 3GPP-based PRS into the larger PNT ecosystem? How long would adoption by these other equipment manufacturers and service providers take? More broadly, would the NextNav PNT solution address aviation and maritime needs for complementary PNT?

5G Resilience to Interference from Incumbent Lower 900 MHz Band Operations. As noted below, 5G signals are likely to cause substantial interference to incumbent users of the Lower 900 MHz Band. However, studies have also shown interference to 5G from incumbent users. Tolling readers are expected to reduce 5G coverage and degrade

¹⁴ See NextNav, *Strengthening the National Positioning, Navigation, and Timing (PNT) Infrastructure*, Q4 Investor Presentation, at 7 (2026), https://s28.q4cdn.com/906934827/files/doc_financials/2025/q4/NextNav-Q4-2025-Investor-Presentation.pdf.

¹⁵ See, e.g., Letter from Ecobee, Itron & Landis+Gyr to FCC, WT Docket Nos. 25-110 & 24-240, at 3-4 (Mar. 9, 2026) (“Critical Infrastructure Ex Parte”), <https://www.fcc.gov/ecfs/document/1030933755065/1>.

¹⁶ NextNav Petition at 22.

quality of service.¹⁷ Similarly, incumbent Part 15 devices are likely to cause significant interference to 5G uplink signals deployed in the band, “border[ing] on complete denial of service in some scenarios.”¹⁸ NextNav proposes to eliminate rules unique to unlicensed operations in the Lower 900 MHz Band that prevent NextNav from claiming harmful interference by Part 15 devices that meet certain conditions.¹⁹

- Based on the technical evidence in the record (which NextNav has not refuted), how should the FCC weigh interference from incumbent operations *into* NextNav’s proposed 5G solution in assessing the viability of the NextNav proposal?
- How have unlicensed device manufacturers and users of unlicensed services relied upon the “safe harbor” adopted in the FCC’s rules more than 30 years ago and which protects them from claims of harmful interference? Has the safe harbor contributed to the wide array of systems, including public safety and critical infrastructure systems, that have deployed in this band?
- Given the weight of the evidence in the record, should any 5G service authorized in the band be subject to the existing safe harbor? Can the Commission eliminate the safe harbor when NextNav has failed to submit any evidence to refute the technical analyses demonstrating that 5G operations would experience interference from Part 15 devices?
- To address interference concerns broadly, should the Commission consider adopting guard bands within the proposed 15-megahertz license to minimize interference among adjacent spectrum uses? Would any amount of guard band permit coexistence?

2. NextNav’s 5G Operation’s Impact on Tolling and Other Licensed Use of the Lower 900 MHz Band.

5G / Tolling Coexistence Analysis Static Assessment v. Real World. NextNav asserts that full-power commercial 5G operations in newly configured, licensed 902-907 MHz and 918-928 MHz frequencies would not cause harmful interference to tolling and other licensed operations sandwiched in between, in the 907-918 MHz band. To support its claim, NextNav conducted lab testing of a static environment, testing one tolling reader, one protocol, and one transponder at a time in a single highway lane scenario.

¹⁷ Neology, *Neology Response to NextNav Criticism of Neology Technical Study on Coexistence Between 5G NR and Non-Multilateration LMS Highway Tolling Systems Under NextNav’s Proposed Lower 900 MHz Band Plan*, at 18-25 (Mar. 19, 2026), <https://www.fcc.gov/ecfs/document/10320835606077/2>, attached to Letter from Crest Hill Advisors, on behalf of Neology, Inc. to FCC, WT Docket Nos. 24-240 & 25-110 (Mar. 20, 2026).

¹⁸ LS Telecom, *RAIN <> NextNav Interference Analysis*, Study for RAIN Alliance Inc., at 25 (Jan. 2026), attached to Letter from RAIN Alliance Inc. to FCC, WT Docket Nos. 24-240 & 25-110 (Jan. 19, 2026); see also WISPA – The Association for Broadband Without Boundaries (“WISPA”), *Technical Report: Flaws in the NextNav Study*, at 3 (Dec. 2025), attached to Ex Parte Letter from WISPA to FCC, WT Docket No. 24-240, RM-11989 (Dec. 8, 2025) (finding that “[t]he highest likelihood of [incumbent users] causing interference to NextNav’s proposed operation is in the uplink band, 902-907 MHz, because the typical uplink will be from a handset, at only 200 mW. This is lower than the Part 15 limit.”).

¹⁹ 47 C.F.R. § 90.361.

- The record points out that tolling increasingly involves open road tolling at highway speeds, with a “read” window as short as 80 milliseconds, multiple reader antennas using different protocols operating simultaneously across multiple lanes, and with multiple vehicles and variable multi-path reflections from vehicles, signage, and other aspects of the roadside environment.²⁰ Does a reliable coexistence determination require additional, more comprehensive and more sophisticated analysis than the NextNav assessment?

NextNav Study’s Input Parameters and Anomalous Results. NextNav’s technical analyses of 5G impacts to licensed tolling operations contained flawed inputs and unexplained results, including: (i) base station power levels at 1/8th the power level NextNav has proposed for rural base stations and 1/4th the power level proposed for urban areas; (ii) artificially low cell and handset loading factors; (iii) random placement of 5G handsets in the cabin space of a vehicle even though handsets are most often within one meter of a tolling transponder mounted to the windshield; (iv) frequency separation between the 5G signal and tolling signal even though its proposal would place 5G adjacent to tolling signals; (v) no testing of the impact of 5G operations on the “write” functionality that some electronic toll operations rely on for features like HOV lane enforcement; and (vi) study results that showed an increase in interference with greater frequency separation between the 5G signal and tolling system in one instance but a decrease with greater frequency separation in another.

- Can the FCC rely upon modeling with these assumptions and findings?

Record of Evidence of NextNav 5G Interference to Tolling Operations. The record contains multiple studies from tolling stakeholders showing how 5G in the Lower 900 MHz Band will cause harmful interference to tolling.

- Studies show that Lower 900 MHz Band 5G base stations and 5G-enabled mobile devices located in a vehicle would cause harmful interference into toll readers on gantries and into transponders on vehicle windshields.²¹ How do these studies compare to the NextNav analysis?
- Many active transponders rely on a “sleep” mode to conserve battery power when not actively sending data to a tolling reader. When vehicles are in the vicinity of Lower 900 MHz Band 5G base stations (regardless of whether tolling facilities are nearby), 5G signals will unnecessarily activate transponders out of sleep mode and can result in false triggering.²² Will such activity deplete transponder batteries and

²⁰ Letter from E-ZPass Group (“E-ZPass”) & Int’l Bridge, Tunnel & Turnpike Ass’n (“IBTTA”) to FCC, WT Docket Nos. 24-240 & 25-110, at 2 (Dec. 5, 2025).

²¹ Mark Sturza, 3C Systems Co., *Expert Review of Neology’s Coexistence Study*, at 3, <https://www.fcc.gov/ecfs/document/1215053326809/3>, attached to Letter from Crest Hill Advisors, on behalf of Neology, Inc., to FCC, WT Docket Nos. 24-240 & 25-110 (Dec. 15, 2025).

²² Kapsch TrafficCom, *Report of Laboratory Testing and Impact Analysis for Kapsch NM-LMS Product against Interference from NextNav Proposed Usage of the LMS Spectrum*, at 60 (Mar. 19, 2026), <https://www.fcc.gov/ecfs/document/10319861403890/1>; E-ZPass & IBTTA, *NextNav’s 5G/Tolling Study: Deeply Flawed and Inadequate to Support NextNav Conclusions*, at 19 (Dec. 2025),

require premature tag replacement for tens of millions of tag users? How does premature transponder triggering affect successful read rates in roadway toll zones?

3. **NextNav's 5G Operation's Impact on Unlicensed Use of the Lower 900 MHz Band.**

5G Operations' Impact on Unlicensed Devices in the Lower 900 MHz Band. NextNav has proposed that the FCC eliminate the Lower 900 MHz Band rule that it demonstrate, through actual field tests, that its operations do not cause unacceptable levels of interference to unlicensed devices.²³ Contrary to NextNav's assertions, several parties have submitted technical studies demonstrating that high-power 5G operations in the Lower 900 MHz Band will cause serious degradation or disruption of Part 15 devices. For example, a study by Pericle Communications found that "receiver sensitivity [in Part 15 devices] would significantly deteriorate, and both co-channel and adjacent channel interference would be so drastic as to make the Lower 900 MHz Band unusable for most devices in large parts of the service area."²⁴

- Based upon NextNav's own assertions that 5G operations will not harm unlicensed device operations, is there any reason to eliminate the existing requirement in rule 90.353(d), which has facilitated coexistence and deployments in the band since the rule's adoption in 1995?
- Should any 5G service authorized for deployment in the Lower 900 MHz Band be subject to the requirement that the licensee demonstrate through actual field tests that its operations will not cause unacceptable levels of interference to unlicensed devices?

Assessment and Comparison of NextNav's Current and Proposed Maximum Power.

NextNav claims that, under its proposal, Part 15 operators will be less susceptible to interference given its suggested revisions to the maximum emissions permitted within a given bandwidth.²⁵ Opponents have pointed out that to make its case about the existing rules, NextNav would need to deploy a large number of unique antennas on a single tower to create an amount of power equivalent to the maximum power it seeks under its proposed rule changes.²⁶

<https://www.fcc.gov/ecfs/document/1210193498906/2>, attached to Ex Parte Letter from E-ZPass FCC, WT Docket Nos. 24-240 & 25-110 (Mar. 2, 2026). See also TransCore, *NextNav 5G NR Interference Tolerance Testing to E6 & Other Readers & Tags*, Bench Test Report at 21, attached to Letter from TransCore to FCC, WT Docket Nos. 24-240 & 25-110 (Mar. 2, 2026).

²³ 47 C.F.R. § 90.353(d).

²⁴ Pericle Communications Co., *Radio Coexistence Study Between Lower 900 MHz Incumbents and Potential 5G Network*, study for Security Industry Association ("SIA"), at 2 (Sept. 9, 2025), attachment 3 to Letter from SIA to FCC, WT Docket Nos. 25-110 & 24-240 (Sept. 12, 2025).

²⁵ NextNav, *5G NR and Unlicensed Part 15 Technologies in the Lower 900 MHz Band, A Coexistence Analysis*, at 9 ("NextNav Feb. 2025 Technical Report"), attached to Ex Parte Letter from NextNav FCC, WT Docket No. 24-240 (Feb. 27, 2025).

²⁶ Reply Comments of Neology and Opposition to NextNav PFR, WT Docket No. 24-240, RM-11989, at 8-9 (Sept. 20, 2024).

- Is it reasonable to assume that NextNav would deploy as many as 80 unique antennas on a single tower under its current licenses, such that it would transmit at an equivalent power level to what it requests in its proposed rule changes? Is it reasonable for the Commission to consider the power levels of a theoretical but inoperable system when comparing the current rules to NextNav’s proposed changes?

Relevance of Mitigation Techniques Employed by Part 15 Devices Operating Under the Current Rules. NextNav has claimed that several unlicensed technologies operating in the Lower 900 MHz Band “are designed for an active radiofrequency environment and can readily operate in the challenging conditions other Part 15 devices create.”²⁷ However, these mitigation measures are largely ineffective in the face of nearby wide-channel, high-power 5G transmissions.²⁸ Moreover, not all Part 15 devices incorporate these mitigation techniques.²⁹

- What percentage of Part 15 devices deployed today in the U.S. include capabilities like frequency hopping spread spectrum (“FHSS”), and what subchannels within the 902-928 MHz band are included in FHSS? How will high-power, 5G operations in portions of the Lower 900 MHz Band impact FHSS-capable devices operating in the band? How many FHSS devices would need to be physically modified or replaced based on their current ability to hop throughout the band (and what costs would be incurred)?³⁰
- What percentage of Part 15 devices deployed in the U.S. today are not frequency agile or do not include FHSS capabilities, and would require physical replacement as a result of NextNav’s proposal?
- What negative impacts would introducing high-power, 5G signals have on unlicensed device resiliency, battery life, and other performance characteristics (especially devices that are fixed and not easily accessible)? How should the FCC measure negative effects on Part 15 devices other than complete denial of service?

4. The NextNav Proposal’s Economic Impact on Incumbent Operations.

Economic Impact and Replacement Costs for Licensed Tolling Interests. On the one hand, NextNav said of licensed incumbents in the band, “[t]o the extent that coexistence requires retuning and other equipment-related costs, NextNav is

²⁷ NextNav Feb. 2025 Technical Report at ii.

²⁸ See Connected Devices for America Coalition Reply Comments, WT Docket No. 25-110, 24-240 & RM-11989, at 14-15 (May 13, 2025) (citing Wi-SUN Alliance Response at 4).

²⁹ *Id.* at 14-15.

³⁰ See Digi Int’l Inc. Comment in Opposition, WT Docket No. 24-240, at ii (Sept. 5, 2024) (“NextNav’s reconfiguration would be inconsistent with the continued ability of Part 15 radios deployed today to operate using 50-channel hopping spread spectrum techniques that allow for higher powered 1 watt radio operations. Repacking into a narrower 11 MHz band from 26 MHz would eliminate this important capability. And to the extent that the repacking occurred, there would be severe performance degradation of these radios due to the loss of bandwidth.”).

committed to accommodations, including financial and technical support[.]”³¹ On the other hand, NextNav’s economic analysis insists that “there is a zero to minimal cost of NextNav’s proposal to either toll readers or toll transponders used in the tolling industry.”³² The tolling industry’s analysis reflects costs of roughly \$6.8 billion, as well as the disruption of years-long equipment replacement that would be required.

- How would the FCC assess reimbursement costs?

NextNav Financial Wherewithal to Reimburse Costs. If the FCC were to move forward with NextNav’s proposal, it would have to ensure that NextNav is financially capable of reimbursing tolling costs pre-deployment of 5G services in the band.

- According to its most recent SEC filing, NextNav generated less than \$4.6 million in revenue in 2025, down from nearly \$5.7 million in 2024, had cash and cash equivalents and marketable securities of \$152.1 million, with an accumulated deficit of \$1.1 billion.³³ Does NextNav have the financial resources and corporate stability to undertake a years-long, massive equipment replacement and maintenance program at a cost of billions of dollars?

Economic Impact and Replacement Costs for Unlicensed Users. NextNav has refused to consider reimbursement payments for unlicensed use and its economic analysis insists there are zero incremental costs to unlicensed users of the band.³⁴ Unlicensed users have refuted NextNav’s underlying premise with showings that (i) 5G signals will cause unacceptable levels of interference to Part 15 devices, in violation of existing FCC rules that require NextNav “to demonstrate through actual field tests that [its] systems do not cause unacceptable levels of interference to [unlicensed] devices,”³⁵ and (ii) the economic impact to unlicensed users resulting from this interference will be significant.

- *UHF Radio Frequency Identification (“RFID”).* A coalition of RFID companies recently reported that there are more than 250 billion items tagged by RFID across a number of industries and sectors.³⁶ What would the direct costs to RFID operations be should the FCC grant NextNav’s petition? What would the indirect costs to RFID operations be, in terms of downtime of systems, loss of economic surplus, reduced first responder safety, and other costs?
- *Critical Infrastructure.* Several critical infrastructure companies have provided evidence that the consumer-facing impacts of NextNav’s proposal on Advanced

³¹ Comments of NextNav, WT Docket No. 25-110, at 22-23 (Apr. 28, 2025).

³² Brattle, Brattle Second Supplemental Report, at 12 (“NextNav Second Economic Supplement”), attached to Letter from NextNav Inc. to FCC, WT Docket Nos. 24-240 & 25-110 (July 17, 2025).

³³ NextNav, Annual Report (SEC Form 10-K) at 32, 35 (Mar. 17, 2026), <https://d18rn0p25nwr6d.cloudfront.net/CIK-0001865631/986333ca-ac02-4e61-9ea2-cbd6f4bad694.pdf>.

³⁴ NextNav Second Economic Supplement at 2.

³⁵ 47 C.F.R. § 90.353(d).

³⁶ Ex Parte Letter from Avery Dennison Corp., et al. to FCC, WT Docket Nos. 24-240 & 25-110, RM-11989, at 1 (Jan. 23, 2026) (“RFID Ex Parte”), <https://www.fcc.gov/ecfs/document/1012356750832/1>.

Metering Infrastructure (“AMI”) could be upwards of \$100 billion.³⁷ What will the direct costs to consumers and other users of AMI be should the FCC grant NextNav’s petition? What will the indirect costs to AMI be, in terms of downtime of systems, additional energy consumption, and other costs?

- *Costs to Other Incumbent Users.* The record is replete with evidence of the hundreds of millions (if not billions) of incumbent Part 15 devices deployed in the Lower 900 MHz Band. What will the direct and indirect costs to consumers and other users of these devices be should the FCC grant NextNav’s petition and incorporate 5G in the Lower 900 MHz Band? In all cases, does the current condition on NextNav’s licenses that protects Part 15 devices require that it reimburse incumbent users for their costs to mitigate or respond to interference from 5G signals deployed in the band? Does NextNav have the financial resources to fund replacement, retuning or other efforts to ensure that consumers and other users of unlicensed Lower 900 MHz Band devices are made whole in the event the FCC grants the petition?

5. National Security, Federal, and Public Safety Impacts.

National Security. UHF RFID is an American-led technological standard, but if NextNav 5G renders UHF RFID on the Lower 900 MHz Band inoperable, current users may be forced to turn to a competing technology championed by Chinese companies.³⁸

- How should the Commission measure the national security costs associated with a Chinese-favored technology replacing the American-led standard for RFID.
- Today, that technology is more costly to consumers and would subject U.S. industries to a hostile nation’s preferred standard.³⁹ What are the costs of losing RFID access to the Lower 900 MHz Band?

Expansive Federal Users. Today, several Federal departments and agencies have frequency assignments for radars and other uses in the Lower 900 MHz Band or use Lower 900 MHz Band unlicensed equipment to fulfill their missions. For example, the Department of War requires passive RFID for items acquired under its contracts,⁴⁰ and the Department of Homeland Security operates RFID systems to support law enforcement operations.⁴¹

³⁷ See Critical Infrastructure Ex Parte at 2.

³⁸ RFID Ex Parte at 2 n.4 (“Research contributions from Chinese companies advocate for the use of Ambient IoT (Manchester encoding) rather than RFID (Miller/FM0 encoding) for tracking and location applications,” citing 3GPP submissions from Huawei, ZTE, and other Chinese entities).

³⁹ *Id.* at 2.

⁴⁰ Assistant Secretary of War (Sustainment), RFID SUPPLIER INFO & FAQs, https://www.acq.osd.mil/asds/log/RFID_FAQs.html (last visited Mar. 23, 2026).

⁴¹ The two systems that make up the majority of the DHS frequency assignments for RFID systems are the: Secure Electronic Network for Travelers’ Rapid Inspection (SENTRI) system operated by U.S. Citizenship and Immigration Service with devices installed inside certain passports; and Vehicle and Cargo Inspection System (VACIS), which uses gamma rays to produce an image of the contents of a container for review by the Customs and Border Protection inspector.

- How many Federal departments or agencies currently rely upon devices or services that operate in the Lower 900 MHz Band, and what are the categories or types of Federal operations in the band? How much taxpayer money has the U.S. government invested in Lower 900 MHz Band equipment?
- What Federal missions would be negatively impacted as a result of NextNav's 5G plan for the Lower 900 MHz Band?

Public Safety Impacts. The Association of Public-Safety Communications Officials, the International Association of Chiefs of Police, the International Association of Fire Chiefs, and the National Sheriffs' Association have stated that "NextNav's proposed PNT solutions could negatively affect existing incumbent operations essential to the preservation of life and safety."⁴² Public safety use cases include man down systems, self-contained breathing apparatus systems, wildfire sensors, traffic signal preemption systems, and smoke and carbon monoxide detectors.

- How should the Commission address these public safety applications that would be negatively affected by NextNav's proposal?
- How should the Commission address the impact on other life safety uses in the band, including fire alarm, home invasion detection, medical alert/monitoring, panic buttons for domestic abuse victims and other vulnerable citizens, and fall detectors for the elderly?

* * *

For the reasons set forth above, the undersigned urge the FCC to account for the substantial record of evidence that already exists in opposition to NextNav's proposal and, at a minimum, ask specific and targeted questions regarding the structural, technical, economic, national security, public safety, and other concerns the proposal raises.

⁴² Int'l Ass'n of Fire Chiefs et al. Comments in Opposition to NextNav PFR, WT Docket Nos. 24-240 & 25-110, at 1 (Nov. 13, 2025), <https://www.fcc.gov/ecfs/document/1119097196447/1>.

Regards,

/s/ Avi Rosenthal

Avi Rosenthal
Chair
**Connected Devices for
America Coalition**

/s/ PJ Wilkins

PJ Wilkins
Executive Director
E-ZPass Group

/s/ Mark Chung

Mark Chung
Executive Director & CEO
**International Bridge, Tunnel,
and Turnpike Association
(IBTTA)**

/s/ Kevin Grove

Kevin Grove
Director, Safety & Technology
Policy
**American Trucking
Associations (ATA)***

/s/ Tobin Richardson

Tobin Richardson
President & CEO
**Connectivity Standards
Alliance**

/s/ Olivier Beaujard

Olivier Beaujard
Chair
LoRa Alliance

/s/ David French

David French
EVP of Government Relations
**National Retail Federation
(NRF)**

/s/ Aileen Ryan

Aileen Ryan
President & CEO
RAIN Alliance Inc.

/s/ Justin Goldberger

Justin Goldberger
Vice President, Technology
Policy
**Retail Industry Leaders
Association (RILA)**

/s/ Alex Roytblat

Alex Roytblat
Vice President Worldwide
Regulatory Affairs
Wi-Fi Alliance

/s/ Louis Peraertz

Louis Peraertz
Vice President of Policy
**WISPA – The Association for
Broadband Without
Boundaries**

* In addition to the American Trucking Associations, in its role as a federation with state trucking association affiliates, the following 21 state associations also sign onto this letter: Arizona Trucking Association, California Trucking Association, Motor Transport Association of Connecticut, Florida Trucking Association, Idaho Trucking Association, Indiana Motor Truck Association, Iowa Motor Truck Association, Kansas Motor Carriers Association, Maryland Motor Truck Association, Michigan Trucking Association, Montana Trucking Association, Nebraska Trucking Association, Nevada Trucking Association, New Jersey Motor Truck Association, North Carolina Trucking Association, North Dakota Motor Carriers Association, Rhode Island Trucking Association, Virginia Trucking Association, Washington Trucking Associations, West Virginia Trucking Association, and Wyoming Trucking Association.

cc (via email): Arpan Sura
 Will Holloway
 Edyael Casaperalta
 Joel Taubenblatt
 Andrew Hendrickson



November 13, 2025

VIA ELECTRONIC FILING

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street NE
Washington, DC 20554

RE: *Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking* (WT Docket No. 24-240); *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions* (WT Docket No. 25-110)

Dear Ms. Dortch:

On behalf of the membership of the International Association of Fire Chiefs (IAFC), the International Association of Chiefs of Police (IACP), the Association of Public-Safety Communications Officials-International (APCO), and the National Sheriffs' Association (NSA), we thank the Federal Communications Commission (FCC) for the opportunity to provide a public safety perspective on NextNav's Petition for Rulemaking ("*NextNav Petition*") seeking to alter the rules on the 902-928 MHz band (Lower 900 MHz Band) and the related Notice of Inquiry on Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions.¹

We recognize NextNav as a leader in determining the accurate location of a caller in a building and acknowledge their work in developing technology to ascertain the location of public safety responders in buildings.

However, as the leadership of America's public safety services, we believe NextNav's proposed PNT solutions could negatively affect existing incumbent operations essential to the preservation of life and safety. Thus, as explained below, we respectfully urge the FCC to deny the *NextNav Petition* and refrain from further action on proposals outlined in the *PNT NOI* to the extent they would require changes to the Lower 900 MHz band.²

Evidence from recent reports and studies, such as the engineering review submitted into the record by Pericle,³ highlight potential risks of NextNav's proposal to critical life safety systems. These systems are prevalent throughout our country, especially in Americans' homes and businesses. The rule changes requested in the *NextNav Petition* could have significant negative consequences for public safety.

Currently, unlicensed devices operate in the Lower 900 MHz Band, including many types of life safety technology that are used by public safety agencies and homeowners on a daily basis. Altering the rules for this band, as NextNav proposes, risks creating interference with these devices, which could compromise the reliable

¹ NextNav Petition for Rulemaking, Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz) (filed Apr. 16, 2024) ("*NextNav Petition*"); *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, WT Docket No. 25-110, Notice of Inquiry, FCC 25-20 (Mar. 28, 2025) ("*PNT NOI*").

² *PNT NOI* at para. 29 (seeking comment on PNT technologies that rely on or incorporate solutions provided by NextNav).

³ See Radio Coexistence Study Between Lower 900 MHz Incumbents and Potential 5G Network, Pericle Communications Company (September 9, 2025).

operation of technologies relied upon for public safety and emergency response. The following are examples of devices that could be affected if NextNav's proposals were allowed to proceed:

- **Man down systems/solutions.** These devices and solutions help provide public safety agencies with the location of first responders and other pertinent life-safety data while on the scene of an incident. They are especially critical for public safety personnel, because they provide critical tracking data for first responders in unfamiliar settings.
- **Self-Contained Breathing Apparatus (SCBA) systems.** SCBA systems provide respiratory protection for first responders in hazardous environments, including fire and areas with toxic gas. These devices may incorporate connectivity features over the Lower 900 MHz band to monitor firefighter status, air supply levels, and environmental conditions. This enables remote monitoring of air cylinder pressures, automatic alerts if a wearer is in distress or immobile, and integration with incident management software for real-time safety oversight.
- **IoT wildfire sensing and wind profile radars.** Connected cameras and sensors equipped with AI use the Lower 900 MHz band to detect environmental conditions conducive to wildfires and create wind predictions for wildfire mitigation. These systems provide early warning and situational awareness to inform public safety decision-making and resource deployment.
- **Preemption of traffic signals.** These devices help emergency vehicles override typical traffic signal operations. They ensure that emergency vehicles have the right-of-way and can reach the incident scene in a quick and timely manner.
- **Automatic utility gas/electric shut off capabilities.** When first responders encounter a scene where live electricity or a gas leak is present, often their first call is to utility companies. Remote shut-off systems operate on the Lower 900 MHz Band. If gas and electric companies cannot operate their remote shut off systems, first responders' lives and safety could be at risk.
- **Smoke and carbon monoxide detectors:** These detectors can be found in the homes of most American citizens. These devices alert people to unsafe levels of smoke or carbon monoxide present in residences or businesses, so that people can evacuate safely. These detectors are often connected directly to alarm companies to allow first responders to arrive on the scene more quickly.

The IAFC, IACP, APCO, and NSA appreciate the opportunity to comment on NextNav's proposal for the Lower 900 MHz band. If the rules governing the use of devices in the Lower 900 MHz band are changed in accordance with NextNav's proposal, many unlicensed life-safety devices may experience reduced functionality or operational limitations that place first responders and the public at risk. Furthermore, NextNav has not presented any proposals that we believe will prevent these potential impacts to critical life-safety systems or measures to mitigate these disruptions should they occur.

In summary, while we appreciate the Commission's ongoing exploration of PNT technologies and acknowledge the potential of the various approaches outlined in the *PNT NOI*, we urge the FCC to consider the critical implications of NextNav's proposal and deny their petition for rulemaking, as well as any proposals in the *PNT NOI* that would require changes to the Lower 900 MHz band. Instead, we encourage the FCC to continue pursuing alternative PNT solutions to support public safety while ensuring that incumbent life-safety systems remain fully protected.

Respectfully,

International Association of Fire Chiefs (IAFC)

International Association of Chiefs of Police (IACP)

Association of Public-Safety Communications Officials-International (APCO)

National Sheriffs' Association (NSA)



July 17, 2025

VIA ECFS

Marlene H. Dortch, Secretary
Federal Communications Commission
45 L Street, NE
Washington, DC 20554

Re: *Wireless Telecommunications Bureau and Office of Engineering and Technology
Seek Comment on NextNav Petition for Rulemaking (WT Docket No. 24-240);
Promoting the Development of Positioning, Navigation, and Timing Technologies
and Solutions (WT Docket No. 25-110)*

Dear Ms. Dortch:

E-ZPass Group and the International Bridge, Tunnel & Turnpike Association (“IBTTA”) respectfully submit the following letter, signed by 44 operators of tolled highway, bridge, and tunnel facilities located in 22 states, who oppose the NextNav Inc. proposal that would have the FCC reconfigure the Lower 900 MHz band (902-928 MHz) and convert its licenses to full-power 5G – to the detriment of co-equal licensees in the band including tolling agencies.

The Lower 900 MHz band provides the connectivity between toll collection gantries and over 100 million in-vehicle transponders across the United States. Electronic toll collection keeps Americans and commercial goods traveling at highway speeds, reduces congestion, improves transportation efficiencies, and enhances road safety. And critically, toll revenue provides strong financial metrics so debt issuers can maintain credit quality and secure capital to fund our nation’s roads and bridges.

NextNav’s proposal would undermine electronic toll system performance, create revenue loss, increase cost of collection, disrupt consumers, and upend the efficient, accurate and timely collection of tolls that is critical to America’s roads and bridges, the states, localities, other operators and bondholders that fund them, and the traveling public.

Respectfully submitted,

/s/ PJ Wilkins

PJ Wilkins
Executive Director
E-ZPass Group

/s/ James Hofmann

James Hofmann
President
**International Bridge, Tunnel &
Turnpike Association**

Attachment

July 17, 2025

VIA ECFS

Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street, NE
Washington, DC 20554

RE: *Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking* (WT Docket No. 24-240; RM-11989);
Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions (WT Docket No. 25-110)

Dear Ms. Dortch:

The 44 undersigned operators of tolled highway, bridge, and tunnel facilities located in 22 States write the Federal Communications Commission (FCC) to underscore how important the current configuration and rules for the Lower 900 MHz band (902-928 MHz) are to U.S. electronic toll collection (ETC) systems. Toll facilities and systems are essential to keeping Americans and commercial goods moving and are fundamental to the quality of life and economic vitality of the country. The nation's toll roads and bridges generate revenues that are vital to the operation of critical transportation assets and the investments required to maintain the safety, reliability, and efficiency of these facilities. Because transportation infrastructure investment is primarily financed with long-term debt secured by the collection of tolls, the efficient, accurate and timely collection of tolls is critical to those facilities, the bondholders, and the traveling public.

A proposal by NextNav, Inc. asks the FCC to upend long-standing licensing and technical rules governing the Lower 900 MHz band to allow high-power 5G wireless broadband to operate in the band on a co-equal basis with the licenses held by toll operators and used to provide ETC.¹ NextNav's goal is to introduce its proprietary positioning, navigation, and timing (PNT) capability that would ride on that 5G network. We take no view on the merits of that PNT technology, but we oppose NextNav's proposal to fundamentally change the nature of the Lower 900 MHz band, reduce the spectrum available to electronic tolling by more than 20 percent, and disrupt toll operations through degraded system performance. Notably, the FCC has before it

¹ See Petition of NextNav Inc. for Rulemaking, WT Docket No. 24-240 (Apr. 16, 2024). Unless otherwise noted, all filings referenced here are to this FCC docket.

other possible PNT solutions that would have no impact on the Lower 900 MHz and the users of that band.²

Tolling agencies' licenses in the Lower 900 MHz band enable wireless connectivity between ETC systems and in-vehicle transponders, permitting toll collection while minimizing manual collection at traditional toll plazas. ETC operations reduce traffic congestion and delays, improve transportation efficiencies, enhance road safety, support motorist convenience, and ensure accurate revenue collection for transportation operators.

NextNav's proposal would disrupt the spectrum environment in the Lower 900 MHz band in ways that risk irreparably disrupting the electronic tolling systems that millions of Americans rely on. The record developed in this proceeding shows that in the absence of toll systems performing at today's high levels of performance and accuracy, consumers, enterprises, and transportation companies would encounter more traffic congestion, backup, and delays. Degraded performance and accuracy would likely result in billing errors as well. Vehicle idling, emissions, fuel consumption and other costs from traffic congestion would increase.³

A coalition of tolling organizations recently released an Economic Study of the impacts of NextNav's proposed realignment of the Lower 900 MHz band used by U.S. electronic tolling and many other applications.⁴ The report was commissioned to set the record straight from misleading assumptions and conclusions put forth by NextNav in a study issued in late 2024 by the Brattle Group. The toll coalition's economic impact analysis projected that "replacing tolling transponders, upgrading roadside facilities, and subsequent revenue leakage would be at least \$6.8 billion."⁵ Other uses of the band would also be devastated: the cost to retune and replace unlicensed devices in the band, including RFID devices that support warehouse and fulfillment centers, alarm systems, and lighting and electrical systems, would range between \$27 billion to \$33 billion.

And as we describe here, it would impair the ability of toll agencies around the country to efficiently and effectively collect user fees pledged to transportation infrastructure projects and outstanding debt obligations. Further, the erosion of debt coverage levels from higher operating

² See *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, Notice of Inquiry, FCC 25-20 (rel. Mar. 28, 2025) (*PNT NOI*).

³ See generally Andrew Eilbert et al., *Estimating Emission Benefits of Electronic Open-Road Tolling Conversion Projects*, Paper #1174898 (June 30, 2022), <https://rosap.ntl.bts.gov/view/dot/64625>.

⁴ See Harold Furchtgott-Roth, Furchtgott-Roth Economic Enterprises, *An Economic Analysis of NextNav's Proposal for the Reallocation of Spectrum and the Modification of Rules in the Lower 900 MHz Band* (Apr. 2025) (attached to Comments of International Bridge, Tunnel & Turnpike Association in the *PNT NOI* proceeding (Apr. 28, 2025)).

⁵ *Id.* at 2.

costs and lost revenue will impact funds available for operations and essential investment for America's infrastructure needs.

The NextNav Proposal Endangers Electronic Tolling Revenues That Play an Essential Role in State and Local Budgets for American Infrastructure.

For more than 35 years, ETC has fueled the growth of toll facilities and revenue as an increasingly important funding source for roads, bridges, and other infrastructure, supporting construction, operations, and maintenance. In fact, each year tens of billions of dollars in public toll revenue funds crucial transportation investments and bondholder commitments.⁶ As Moody's Investor Services observes, toll roads generally have "strong financial metrics" and thus help issuers of transportation-related debt maintain credit quality and fund new capital investments.⁷

Disruption to toll collection activities would imperil the ability of States and toll operators to collect revenue that finances transportation projects. To ensure accurate toll collection, tolling equipment is expected to successfully read a transponder and assign it to the correct vehicle in just 80 milliseconds as the vehicle passes through the coverage area of the tolling system's antennae. In highway-speed open-road toll environments, there are often multiple transactions processed simultaneously among as many as three leading tolling protocols. The myriad of communication activity within compressed timeframes must be achieved within accuracy levels of less than 5 misses in 10,000 transactions.⁸

NextNav's proposal would introduce interference and/or receiver overload leading to "increasing missed transponder reads and resulting in more expensive transaction processing, billing errors, diminished consumer confidence, and lost public revenue for state and local governments."⁹ For example, as one tolling authority observed, NextNav's proposal risks "jeopardizing the revenue on which states depend to repay the indebtedness issued to pay for the capital costs of the various roads and for the upkeep of their transportation networks."¹⁰ And another toll operator warned that the NextNav proposal "will impact our individual ability to fulfill our obligations and will disrupt our toll operations."¹¹ We all share these concerns.

⁶ Letter from Chamber Technology Engagement Center, U.S. Chamber of Commerce to FCC at 2 (Oct. 30, 2024).

⁷ Moody's Investor Service, *Toll Roads – US 2024 Outlook – Stable with slowing but still-growing traffic and revenue*, at 1, 5 (Dec. 6, 2023), <https://www.ibtta.org/sites/default/files/documents/Moodys-US-Toll-Roads-2024-Outlook.pdf>.

⁸ Comments of E-ZPass Group at 12-13 (Sept. 5, 2024).

⁹ Opposition of the International Bridge, Tunnel & Turnpike Association at 14 (Sept. 5, 2024).

¹⁰ Comments of Georgia State Road and Toll Authority at 3 (Sept. 5, 2024).

¹¹ Comments of California Toll Operators Committee at 2 (Sept. 4, 2024).

* * *

The NextNav proposal would overwhelm electronic tolling operations in the Lower 900 MHz band, severely impede electronic toll collection, cause massive disruption to millions of ETC users, and reduce toll revenue – jeopardizing the financing that State and local governments, and other operators of tolled facilities, depend on to keep up with today’s roadway demands. Given these risks and consequences, we urge the Commission to deny NextNav’s petition.

Respectfully submitted,

<u>/s/ Ryan Chamberlin</u> The Corridor Agencies Ryan Chamberlin, Chief Executive Director Irvine, CA	<u>/s/ Jennifer Mennucci</u> Golden Gate Bridge, Highway & Transportation District Jennifer Mennucci, CFO/Auditor-Controller San Francisco, CA
<u>/s/ Andrew Fremier</u> Metropolitan Transportation Commission/Bay Area Toll Authority Andrew Fremier, Executive Director San Francisco, CA	<u>/s/ Darrell Johnson</u> Orange County Transportation Authority Darrell Johnson, Chief Executive Officer Orange CA
<u>/s/ Jennifer Crosson</u> Riverside County Transportation Commission Jennifer Crosson, Toll Operations Director Riverside, CA	<u>/s/ Kelly Brown</u> Colorado Department of Transportation Kelly Brown, Chief Tolling Operations Officer Denver, CO
<u>/s/ Pedro Costa</u> Northwest Parkway LLC Pedro Costa, Chief Operating Officer Broomfield, CO	<u>/s/ Shanté A. Hastings, P.E.</u> Delaware Department of Transportation Shanté A. Hastings, P.E., Cabinet Secretary Dover, DE
<u>/s/ Thomas J. Cooke</u> Delaware River & Bay Authority Thomas J. Cooke, Executive Director New Castle, DE	<u>/s/ Michelle Maikisch</u> Central Florida Expressway Authority Michelle Maikisch, Executive Director Orlando, FL
<u>/s/ Jannine Miller</u> State Road & Tollway Authority Jannine Miller, Executive Director Atlanta, GA	<u>/s/ Annie Gillespie, P.E.</u> 6C Coalition Annie Gillespie, P.E., President Atlanta, GA

<u>/s/ Cassandra Rouse</u> Illinois State Toll & Highway Authority Cassandra Rouse, Executive Director Downers Grove, IL	<u>/s/ Scott Gemmell</u> Skyway Concession Company, LLC Scott Gemmell, VP of IT Chicago, IL
<u>/s/ Andre J. Briere</u> Maine Turnpike Authority Andre J. Briere, Colonel, USAF (ret.), Executive Director Portland, ME	<u>/s/ Bruce Gartner</u> Maryland Transportation Authority Bruce Gartner, Executive Director Baltimore, MD
<u>/s/ Stephen Collins</u> Massachusetts Department of Transportation Stephen Collins, Director of Statewide Tolling Boston, MA	<u>/s/ Veronica Latonio</u> United Bridge Partners, LLC Veronica Latonio, VP Tolling & Back Office Operations Bay City, MI
<u>/s/ Brad Larsen</u> Minnesota Department of Transportation Brad Larsen, MN E-ZPass Policy & Planning Director St. Paul, MN	<u>/s/ John T. Hanson</u> Delaware River Port Authority John T. Hanson, Chief Executive Officer Camden, NJ
<u>/s/ James D. Carone</u> New Jersey Turnpike Authority James D. Carone, Executive Director Woodbridge, NJ	<u>/s/ Stephen F. Dougherty</u> South Jersey Transportation Authority Stephen F. Dougherty, Executive Director Hammonton, NJ
<u>/s/ Thomas A. Boyle, P.E.</u> Buffalo and Fort Erie Public Bridge Authority Thomas A. Boyle, P.E., Chief Operating Officer Buffalo, NY	<u>/s/ Frank G. Hoare</u> New York State Thruway Authority Frank G. Hoare, Esq., Executive Director Albany, NY
<u>/s/ Diannae C. Ehler</u> Port Authority of New York & New Jersey Diannae C. Ehler, Director, Tunnels, Bridges & Terminals Manhattan, NY	<u>/s/ Timothy Sturick</u> Thousand Islands Bridge Authority Timothy Sturick, Executive Director Alexandria Bay, NY
<u>/s/ Catherine T. Sheridan, P.E.</u> Triborough Bridge & Tunnel Authority Catherine T. Sheridan, P.E., President TBTA Manhattan, NY	<u>/s/ James J. Eden</u> North Carolina Turnpike Authority James J. Eden, Executive Director Raleigh, NC

<u>/s/ Ferzan M. Ahmed</u> Ohio Turnpike & Infrastructure Commission Ferzan M. Ahmed, Executive Director Berea, OH	<u>/s/ Tim Gatz</u> Oklahoma Department of Transportation Tim Gatz, Executive Director Oklahoma City, OK
<u>/s/ Joe Echelle</u> Oklahoma Turnpike Authority Joe Echelle, Executive Director Oklahoma City, OK	<u>/s/ Joseph J. Resta</u> Delaware River Joint Toll Bridge Commission Joseph J. Resta, Executive Director Yardley, PA
<u>/s/ Mark P. Compton</u> Pennsylvania Turnpike Commission Mark P. Compton, Chief Executive Officer Middletown, PA	<u>/s/ Lori Silveira</u> Rhode Island Bridge Authority Lori Silveira, Executive Director Jamestown, RI
<u>/s/ James Bass</u> Central Texas Regional Mobility Authority James Bass, Executive Director Austin, TX	<u>/s/ Julià Monsó</u> Cintra Julià Monsó, Vice President CEO CTS Austin, TX
<u>/s/ James Hofmann</u> North Texas Tollway Authority James Hofmann, Executive Director and CEO Plano, TX	<u>/s/ Ananth Prasad</u> SH 130 Concession Company Ananth Prasad, Chief Executive Officer Buda, TX
<u>/s/ Tracey Johnson</u> Texas Department of Transportation Tracey Johnson, Project Finance and Toll Operations Division Austin, TX	<u>/s/ Anna Bonet</u> Elizabeth River Crossings, An Abertis Company Anna Bonet, Chief Executive Officer Portsmouth, VA
<u>/s/ Lorenzo Rubio Beltrán</u> Pocahontas Parkway Lorenzo Rubio Beltrán, General Manager Richmond, VA	<u>/s/ Stephen C. Brich, P.E.</u> Virginia Department of Transportation Commissioner Stephen C. Brich, P.E. Richmond, VA
<u>/s/ Edward Barry</u> Washington State Department of Transportation Edward Barry, Director – Toll Division Seattle, WA	<u>/s/ Parrish French</u> West Virginia Parkway Authority Parrish French, Interim Executive Director Charleston, WV

March 9, 2026

Via ECFS

Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street NE
Washington, DC 20554

Re: Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions (WT Docket No. 25-110); Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking (WT Docket No. 24-240)

Dear Ms. Dortch:

The undersigned parties respectfully submit this letter in response to the Federal Communications Commission's ("FCC" or "Commission") Notice of Inquiry regarding actions the Commission could potentially take to incentivize and support industry efforts to develop complementary Positioning, Navigation, and Timing ("PNT") technologies and solutions.¹ We support the establishment of PNT services that promote national security and the public interest and applaud the Commission's ongoing efforts to promote spectrum efficiency and advanced wireless services. However, NextNav's proposal to repurpose the 902-928 MHz (the "Lower 900 MHz band") for high-power 5G operations risks harm to the public interest, endangers critical infrastructure, threatens public safety, and would impose significant costs on utilities and citizens alike. For these reasons, we urge the FCC to deny NextNav's pending petition for rulemaking and instead focus its resources on facilitating other, more viable commercial PNT alternatives.

ecobee is an industry leading smart thermostat company with over 4.6 million Part 15 sensors and over 12 million smart thermostats in-market today. ecobee is also a subsidiary of Generac Power Systems, Inc. (NYSE: GNRC), a principal American energy technology company that provides backup power products and energy storage systems for home and business applications, as well as energy monitoring and management devices and services. **Itron** is a global leader in energy, water, smart city, industrial IoT, and intelligent infrastructure services. To date, it has shipped and deployed more than 230 million devices using the Lower 900 MHz band worldwide, with a majority operating in the USA. **Landis+Gyr** is a global energy

¹ See *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, Notice of Inquiry, 40 FCC Rcd 2641 (2025).

technology leader delivering intelligent solutions that connect devices, data and decisions across the grid. Its mission is to accelerate the energy evolution through purposeful innovation and trusted partnerships. Trusted by more than 3,500 utilities worldwide, Landis+Gyr transforms traditional infrastructure into intelligent, networked systems that provide real-time grid visibility and control.

Together, we estimate that NextNav’s proposal (if approved) **would cost utilities and approximately 200 million ratepayers nationwide upwards of \$100 billion in direct expenses for workarounds and equipment replacement**, plus incalculable indirect costs from lost electrical, water, and gas utility efficiencies and expenses—all at a time when grid capacity and consumer affordability have never been more critical. These risks are easily avoidable as other PNT alternatives can be implemented faster, without such downsides, and with greater long-term viability. Below, we highlight one such PNT alternative so as to provide insight into the real-world costs and risks that NextNav’s proposal would impose on the U.S. utility industry and its rate payers.²

I. NextNav’s Proposed PNT Solution is Inferior to Available Alternatives

The FCC’s evaluation of NextNav’s proposal for the Lower 900 MHz band should carefully consider the breadth of other available PNT alternatives. We thank the National Telecommunications and Information Administration (“NTIA”) for its comprehensive review of such available options and for highlighting the importance of robust – and non-disruptive solutions.³ We will not opine on all available PNT options but instead will highlight in more detail that NextNav’s proposal is inferior to a 3GPP (global cellular standard compliant) Mobile Broadband solution—anchored in 5G Standalone (“5G SA”) networks.⁴

A 5G SA-based PNT solution would leverage existing 5G mobile networks – those deployed and maintained by every major US-based cellular carrier – and use standardized software features to measure signal timing and direction. The 3GPP 5G SA standard⁵ has the

² The network functionality necessary for PNT already exists within the 5G infrastructure. Therefore, NextNav’s proposal to restructure and acquire control over a sizable portion of the Lower 900 MHz band for 5G cellular and LMS is unnecessary for the deployment of PNT solutions.

³ Comments of the National Telecommunications and Information Administration (“NTIA”), Inventory of Complementary, Alternative, and Augmentative PNT Solutions, WT Docket No. 25-110 (filed May 27, 2025).

⁴ *Id.* at 11-12.

⁵ See 3GPP, *Study on NR positioning support (Release 16)*, TR 38.555 (v16.0.0) (Mar. 2019), <https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3501>; see also See 3GPP, *5G System (5GS) Location Services (LCS) Stage 2*, TS 23.273 (v16.7.0) (July 2021), https://www.etsi.org/deliver/etsi_ts/123200_123299/123273/16.07.00_60/ts_123273v160700p.pdf (“TS 23.273”); 3GPP, *NG Radio Access Network (NB-RAN) Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN*, TS 38.305 (v17.0.0) (May 2022), https://www.etsi.org/deliver/etsi_ts/138300_138399/138305/17.00.00_60/ts_138305v170000p.pdf (“TS 38.305”); 3GPP, *NR Physical channels and modulation*, TS 38.211 (v16.2.0) (July 2020), https://www.etsi.org/deliver/etsi_ts/138200_138299/138211/16.02.00_60/ts_138211v160200p.pdf (“TS 38.211”); 3GPP, *NR Multiplexing and channel coding*, TS 38.212 (v16.5.0) (Apr. 2021), https://www.etsi.org/deliver/etsi_ts/138200_138299/138212/16.05.00_60/ts_138212v160500p.pdf (“TS 38.212”).

enormous advantage of leveraging already fully deployed, nationwide networks operated by multiple large, economically stable U.S.-based companies (U.S. major carriers) and is supported by a vast, coordinated cellular industry ecosystem. The necessary standards, existing physical infrastructure and cloud platforms, deeply experienced service providers, and extensive ecosystem of solution component providers are already fully in place.

Comprehensive Positioning, Navigation, and Timing

The 3GPP 5G SA standard delivers a unified platform for both high-accuracy positioning and precise timing:

Positioning & Navigation: 5G SA supports advanced methods standardized in 3GPP Technical Specifications 23.273 and 38.305 to measure how long signals take to travel, to determine the direction from which signals arrive, and to identify nearby cell towers.⁶ These standardized methods ensure reliable and accurate positioning, are designed to function in both indoor and outdoor environments, and support a variety of use cases from emergency services to industrial automation.

Timing Accuracy: 5G SA offers precise time distribution and synchronization. 3GPP Technical Specifications 38.211 and 38.212 define mechanisms that support highly precise time alignment across the network, enabling nanosecond-level synchronization when combined with standardized time-distribution protocols such as IEEE 1588 Precision Time Protocol (PTP) and Time-Sensitive Networking (TSN).⁷ 3GPP's approach to timing in 5G networks is to use precise signals and protocols so that all parts of the network—devices, base stations, and applications—stay tightly synchronized. The standards were developed to support high precision services, precisely like PNT.

3GPP Scale and Maturity

If the Commission determines that a terrestrial-based service is an essential component of a robust, redundant PNT ecosystem, a 3GPP-compliant, 5G SA-based solution is far preferable to NextNav's proposal.

Nationwide 5G SA Rollout: The U.S. is virtually covered by commercial 5G SA deployments from AT&T and T-Mobile supporting Release 16 features; Verizon has deployed a 5G SA-capable core network and supports Release 16 features in many markets, with ongoing expansion.⁸ Together, these ubiquitous 5G infrastructures offer a

⁶ See TS 23.273 § 1; TS 38.305 § 1.

⁷ See TS 38.211 §§ 4, 4.2, 5.3; TS 38.212 § 6.

⁸ Yigal Elbaz, *AT&T 5G Standalone Nationwide*, AT&T Blog (Oct. 8, 2025), <https://about.att.com/blogs/2025/5g-standalone-nationwide.html> (“AT&T 5G-NR SA Announcement”); John Saw, *It's Time to Unleash Network Slicing*, T-Mobile Network Blog (Aug. 28, 2023), <https://www.t-mobile.com/news/network/its-time-to-unleash-network-slicing>; see also Janne Peisa, *et al.*, Ericsson Technology Review - 5G New Radio Evolution (Mar. 2020), <https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/5g-nr-evolution>;

dependable, tested, and resilient backbone for PNT services, and rollout would require no new hardware—only software upgrades for enhanced features.

RedCap and eRedCap Evolution: 3GPP’s Reduced Capability (“RedCap”) variants offer lower costs and longer battery life, enabling inclusion of mobile broadband PNT to lower cost communication devices. The first wave of these devices (RedCap, R16) for industrial IoT is already on the market. The next evolution, (eRedCap, R18) is expected to reach full rollout by 2028–2029, with only software upgrades required for carriers. By building on this existing foundation, adopting new PNT use cases would be rapid and cost-effective.⁹

Coordinated Industry Effort: There is unprecedented alignment across modem, device, infrastructure vendors, and carriers to deliver 5G-based PNT. Both Ericsson and Nokia have already released R16 positioning features,¹⁰ and the existing ecosystem guarantees future interoperability, scalability, and continuous improvement.

Technical and Practical Advantages

The 3GPP solution is well defined and includes planned enhancements to further improve PNT capabilities. No hardware overhauls will be required for these enhancements as they will be delivered via remote software upgrades, leveraging the existing 5G SA infrastructure. Accordingly, the 5G SA approach minimizes costs, risks, and avoids disruptions—contrasting sharply with NextNav’s proposal, which requires new hardware deployments and a widely disruptive spectrum reallocation.

Release 16 (R16): Delivers indoor positioning accuracy of approximately 3 m and outdoor accuracy of 10 m (at 80% confidence), with vertical accuracy targets of ≤ 3 m.¹¹

Dan Jones, *Here's a 5G SA update on the Big 3 US mobile operators*, Fierce Network (Jul. 2025), <https://www.fierce-network.com/wireless/big-3-mnos-us-5g-sa-update>.

⁹ See 3GPP, *Study on support of reduced capability NR devices (RedCap)*, TR 38.875 (Release 17), §§ 4–6 (defining reduced device complexity, power consumption, and performance targets); see also 3GPP, *NR and NG-RAN evolution (Release 18 scope)*, TR 38.874, § 5.2 (describing enhanced RedCap (eRedCap) objectives and evolution). Commercial RedCap deployments are described by AT&T, *AT&T Achieves Nationwide 5G RedCap Coverage* (July 16, 2025), <https://about.att.com/blogs/2025/5g-redcap.html>; Ericsson, *RedCap and eRedCap: Extending 5G to New Device Categories*. Industry analysts project broader eRedCap commercialization in the 2028–2029 timeframe following Release 18 standardization. See ABI Research, *eRedCap on the Verge of Becoming a Reality, but with a Slow Burn Ahead* (Mar. 2, 2026), <https://www.abiresearch.com/market-research/insight/7787525-eredcap-on-the-verge-of-becoming-a-reality>.

¹⁰ Kavitha Majithia, *Ericsson claims SA 5G boost with LBS tech*, Mobile World Live (Jan. 21, 2026), <https://www.mobileworldlive.com/ericsson/ericsson-claims-sa-5g-boost-with-lbs-tech/>; Nokia, *The evolution of 5G New Radio positioning technologies*, <https://www.nokia.com/asset/i/210289/> (“Nokia Positioning White Paper”).

¹¹ See 3GPP, *Study on NR positioning enhancements*, TR 38.855 §§ 6–7 (Release 16 baseline positioning performance assumptions, including meter-level indoor accuracy, ~10 m outdoor accuracy, and vertical accuracy targets); see also 3GPP, *NG-RAN UE positioning*, TR 38.305 § 4.2 (positioning accuracy metrics and vertical positioning objectives).

Release 17 (R17): Improves accuracy to sub-meter levels (horizontal accuracy <1 m at 90% confidence, and vertical accuracy <0.2 m for industrial IoT), with enhanced integrity and latency.¹²

Release 18 (R18): Introduces features like carrier-phase positioning, sidelink enhancements, and RedCap support to enable decimeter-level accuracy and robust timing.¹³

Timing Distribution: Enables nanosecond-level synchronization for sensitive, mission critical applications.¹⁴

Rural Coverage, Security, and Integrity

5G SA networks are expanding rapidly into rural areas, driven by federal and private investment.¹⁵ RedCap and eRedCap devices are specifically designed for cost-effective, wide-area deployment, including in rural and remote environments.¹⁶ Moreover, 3GPP standards include integrity monitoring and resilience against security threats like jamming and spoofing, responding to the critical needs of utilities, transportation, and public safety users.

II. NextNav's Proposal is Economically Indefensible

NextNav's proposal not only promises benefits that (a) exist only in theory, and (b) are exceeded by existing 5G SA technology, but also unjustifiably enriches the company and will cost utilities and consumers more than the total theoretical economic value it offers. As Retired General and Commander of the U.S. Air Force's Space Command, Gen. William Shelton, has observed, NextNav's proposed system "would require massive infrastructure investments beyond what cellular networks have spent decades building," "the company lacks the partnerships, funding, and logistical capability to deploy such an extensive network," and "even if NextNav were to collaborate with cellular providers, there would still be substantial gaps in coverage."¹⁷

Economic Impact

NextNav's claims of "minimal to no impact" to other users of the Lower 900 MHz band is simply not true.¹⁸ Disruptive interference from NextNav's proposed increased transmission

¹² See TR 38.855 at §§ 7.2–7.4 (noting Release 17 positioning enhancements, including sub-meter horizontal accuracy targets, improved vertical accuracy for industrial use cases, and enhanced integrity and latency).

¹³ Hyun-Su Cha, *et al.*, *5G NR Positioning Enhancements in 3GPP Release-18* (Jan. 2024), <https://arxiv.org/html/2401.17594v1>.

¹⁴ PHY-level support for ± 50 μ s alignment (TS 38.211/38.212) combined with IEEE 1588 PTP and TSN.

¹⁵ See AT&T 5G-NR SA Announcement.

¹⁶ Jason Sikes, *AT&T Achieves Nationwide 5G RedCap Coverage*, AT&T Blog (July 16, 2025), <https://about.att.com/blogs/2025/5g-redcap.html>.

¹⁷ See Ret. Gen. William Shelton, *The FCC must strengthen GPS resilience*, Washington Examiner (Mar. 20, 2025), <https://www.washingtonexaminer.com/restoring-america/opinion-restoring-america/3352027/fcc-must-strengthen-gps-resilience/>.

¹⁸ *Ex Parte* Letter from Aileen Ryan, President, RAIN Alliance *et al.* to Marlene H. Dortch, Secretary, FCC, WT Docket Nos. 25-110 & 24-240 (filed Sept. 10, 2025).

power levels and reduced available bandwidth in the Lower 900 MHz band would largely interrupt data traffic and critical utility operations like outage restoration, gas safety issue prevention, and fault location and isolation, requiring wholesale replacement of smart electric, gas, and water management hardware, merely to accommodate NextNav's sub-optimal PNT proposal.

Electric, gas, and water utilities face rising demands due to population growth, economic expansion, and increased use of energy for vehicles and data centers supporting cloud and artificial intelligence technologies. More than 160 million¹⁹ electric, gas and water meters are deployed throughout the U.S. in connection with Advanced Metering Infrastructure ("AMI") and Automated Meter Reading ("AMR") solutions that rely on unlicensed transmissions in the Lower 900 MHz band.

These devices, vital for supplying essential electrical, water, and gas services to about 200 million Americans, are built to rely on the Lower 900 MHz band and cannot be remotely retuned or shifted to other frequencies. Changing the rules to allow NextNav to transmit at much higher power in the band, without the protections currently afforded to unlicensed operations,²⁰ means that more than 160 million electric, gas, and water meters installed in homes, offices, schools, and factories across the U.S. would have to be removed and replaced, a project that would be as costly and complex as it sounds.

In addition, these utility systems are ratepayer-funded through utility commission-approved rate cases which include committed returns on investment and consumer benefits. Utilities are obliged to deliver a minimum of \$16 billion in net economic benefits over the next five years using Lower 900 MHz band-based solutions.²¹ Highly resilient, highly secure, and cost-effective wireless communications are foundational to these rate cases. The market has answered this need with solutions that comply with and depend upon the existing coexistence rules for the Lower 900 MHz band.

Developing and implementing replacement solutions would take an absolute minimum of five years, during which utilities would have to revert to outdated mechanisms like manual meter reading or billing estimates, would have less visibility into their grid for outages, not be able to execute remote disconnects, and would be far less likely to find theft. Developing and rolling out

¹⁹ At least 100 million electric Advanced Metering Infrastructure devices have been deployed using mesh communications systems operating in the Lower 900 MHz spectrum. Additionally, more than 60 million Automated Meter Reading devices leveraging the same spectrum have been provided by Itron alone to utilities in the United States.

²⁰ See 47 CFR §§ 90.353 (d), 90.361.

²¹ Net economic benefit is a forward-looking estimate reflecting, in part, data maintained by the U.S. Energy Information Administration that provides an aggregation of publicly available, state public utility commission approved, electric AMI rate cases. See U.S. Energy Information Administration, *Annual Electric Power Industry Report*, Form EIA-861 (rel. Oct. 7, 2025), <https://www.eia.gov/electricity/data/eia861/>. This figure excludes gas and water AMI and AMR projected economic benefit values and is therefore a conservative figure.

new automated systems that operate in other bands will likely cost a minimum of \$58 billion.²² Additionally, the estimated total remaining book value of these meters is estimated to be \$25 billion. Both the accelerated depreciation and the replacement costs would have to be funded by ratepayers at a time when energy affordability is top of mind for many consumers. This would be an enormous public cost for a PNT solution that, even if delivered as promised, can be similarly provided using existing technology and spectrum resources. These calculations pertain only to the electric AMI sector. Gas and water utilities have millions of additional devices that use unlicensed wireless communications as well. Conservatively, the impact of NextNav's proposal on these devices could add another 50% to total ratepayer cost increases.

In addition to the direct costs to ratepayers, utilities would experience major opportunity costs by redirecting money and attention to the replacement of functioning services rather than to improving resiliency, reliability, and meeting the growing energy needs of the domestic AI and data services sectors.

Earlier in this proceeding, NextNav offered to the Commission a report entitled “Public Benefits of Reconfiguring the Lower 900 MHz Band to Support a Backup and Complement to GPS” (“Brattle Report”) which stated that the “total quantified public value” of NextNav’s proposed terrestrial PTN was approximately \$14.6 billion.²³ Even accepting the economic analysis in the Brattle Report as true (notwithstanding the serious questions, objections, and rebuttals to the Brattle Report that opponents have filed in the record), NextNav would have utilities and consumers pay approximately \$100 billion to receive less than \$15 billion in value, an overcharge of almost 600%. That is, simply, economic irrationality that defies the public interest.

III. Conclusion

We respectfully request that the Commission adopt a balanced approach to PNT alternatives that safeguards public safety, minimizes economic harm, and ensures technical integrity. The nation’s clear need for one or more alternative or complementary PNT solutions is critical and urgent, so the outcome should not depend on the success of massively disruptive, proprietary, and economically inefficient proposals. Rather, the Commission should prioritize economically rational approaches to meet the nation’s PNT needs. The Commission should not, and need not, favor any PNT solution that disproportionately burdens utilities and consumers

²² The U.S. Energy Information Administration (“EIA”) reports that approximately 141 million electric AMI endpoints have been deployed, of which 90% use mesh communications technology. *Id.* A Department of Energy report published in 2016 indicates that the average deployment cost per smart meter is \$344.00. Allowing for inflation, the result is an aggregate value of \$58 billion. See U.S. Dep’t of Energy, Office of Electricity Delivery & Energy Reliability, Advanced Metering Infrastructure and Customer Systems: Results from the Smart Grid Investment Grant Program (Sept. 2016), https://www.energy.gov/sites/prod/files/2017/01/f34/Final%20SGIG%20Report%20-%202016-12-20_clean.pdf.

²³ See Coleman Bazelon & Paroma Sanyal, *Public Benefits of Reconfiguring the Lower 900 MHz Band to Support a Backup and Complement to GPS* 1 (Oct. 18, 2024); attached to Ex Parte Letter from Robert Lantz, General Counsel, NextNav Inc. to Marlene H. Dortch, Secretary, FCC, WT Docket No. 24-240 (filed Oct. 21, 2024).

with unnecessary expenses, threatens public safety, and creates a multi-year delay in modernization of the electrical, gas, and water utility distribution networks.

Regards,

/s/ Ty Roberts

/s/ Jena Ginsburg

/s/ Amith Kota

Ty Roberts

Jena Ginsburg

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VP Product Marketing
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Generac Power Systems, Inc.

Chief Product & Technology
Officer
Landis+Gyr



March 9, 2026

WT Docket Nos. 24-240, 25-110

via ECFS

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street NE
Washington, DC 20554

Re: NOTICE OF INQUIRY - In the Matter of Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions (WT Docket No. 25-110)

Dear Ms. Dortch:

The RAIN Alliance is a non-profit consortium of more than 200 member companies that work to create a smarter and more innovative world using RAIN RFID technology—a standards-based UHF RFID technology using the ISO/IEC 18000-63 protocol.¹ RAIN RFID systems are deployed across critical sectors of the U.S. economy, including retail, logistics, healthcare, and aviation, where they enable inventory management, supply chain visibility, loss prevention, and patient safety applications. There are hundreds of billions of RAIN RFID tags and hundreds of millions of reader devices currently deployed across the United States, operating in the 902-928 MHz band (“Lower 900 MHz Band”) pursuant to Part 15 of the Commission’s rules.

INTRODUCTION

The RAIN Alliance respectfully submits the attached economic analysis by Harold Furchtgott-Roth of Furchtgott-Roth Economic Enterprises (the “RAIN Economic Impact Study,” attached hereto) in response to the Notice of Inquiry in WT Docket No. 25-110² and in opposition to the Petition for Rulemaking filed by NextNav, Inc. (“NextNav”) in WT Docket No. 24-240.³ The RAIN Economic Impact Study quantifies the economic harm

¹ www.therainalliance.org

² See *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, Notice of Inquiry, 40 FCC Rcd 1520, WT Docket No. 25-110 (rel. Mar. 6, 2025).

³ See NextNav, Inc., Petition for Rulemaking, WT Docket No. 24-240 (filed Apr. 16, 2024) (“NextNav Petition”); *Wireless Telecommunications Bureau and Office of Engineering and Technology Seek*



that the NextNav proposal would inflict on RAIN RFID users alone at between \$5.0 billion and \$7.2 billion in direct replacement costs—before accounting for substantial unquantifiable indirect costs and additional harms. This economic analysis complements the LS telcom technical interference analysis that the RAIN Alliance previously submitted,⁴ as well as the comprehensive cost-benefit analysis prepared by Dr. Furchtgott-Roth on behalf of the International Bridge, Tunnel and Turnpike Association (“IBTTA”).⁵

The RAIN Alliance reaffirms its strong support for the Commission’s efforts in WT Docket No. 25-110 to develop resilient, redundant positioning, navigation, and timing (“PNT”) capabilities to complement and back up the Global Positioning System (“GPS”). The United States can and should develop GPS backup capabilities, but it must do so without hamstringing the technologies that already safeguard our economy, consumers, and national defense.

THE ECONOMIC RECORD IN THIS PROCEEDING

NextNav has submitted two economic reports prepared by the Brattle Group in support of its petition. The first Brattle Group study estimated the value of a terrestrial PNT network at \$14.6 billion, relying principally on an “insurance policy” framework that assigned value based on the risk of GPS outages from geomagnetic storms.⁶ A broad coalition of more than 60 industry organizations challenged the Brattle Group’s analysis, identifying critical flaws in its valuation framework—including its reliance on unsupported GPS outage probabilities and its failure to account for limitations of NextNav’s

Comment on NextNav Petition for Rulemaking, Public Notice, DA 24-776, WT Docket No. 24-240 (rel. Aug. 6, 2024).

⁴ LS telcom, *RAIN - NextNav Interference Analysis, Technical Report*, (Jan. 2026) (“LS telcom Study”), attached to Letter from Aileen Ryan, RAIN Alliance, to Marlene H. Dortch, Secretary, FCC, WT Docket Nos. 24-240 and 25-110 (filed Jan. 19, 2026) <https://www.fcc.gov/ecfs/document/101191445810529/2> (“RAIN Alliance Technical Report Letter”).

⁵ Harold Furchtgott-Roth, *An Economic Analysis of NextNav’s Proposal for the Reallocation of Spectrum and the Modification of Rules in the Lower 900 MHz Band* (Apr. 2025) (“IBTTA Economic Analysis Report”), attached to Letter from James Hofmann & Mark F. Muriello, IBTTA, to Marlene H. Dortch, Secretary, FCC, WT Docket No. 24-240, RM-11989 (filed Apr. 29, 2025) <https://www.fcc.gov/ecfs/document/10428203750336/2>.

⁶ Coleman Bazelon & Paroma Sanyal, Brattle Group, *Public Benefits of Reconfiguring the Lower 900 MHz Band to Support a Backup and Complement to GPS* (Oct. 18, 2024) (“Brattle Group Study”), attached to Letter from Robert Lantz, Gen. Couns., NextNav Inc., to Marlene H. Dortch, Secretary, FCC, WT Docket No. 24-240 (filed Oct. 21, 2024) <https://www.fcc.gov/ecfs/document/102119951243/1>.



technology—and emphasizing that the analysis entirely omitted the costs that the proposal would impose on incumbent users of the Lower 900 MHz Band.⁷

Dr. Furchtgott-Roth subsequently prepared a comprehensive cost-benefit analysis on behalf of IBTTA, finding that the actual economic benefits of the NextNav proposal amount to no more than \$1.2-2.1 billion—a fraction of the Brattle Group’s \$14.6 billion figure—and that the overall economic costs would be in the tens of billions of dollars.⁸ The IBTTA Economic Analysis Report demonstrated that NextNav already offers PNT services under the existing rules, and that more than a dozen other companies also offer PNT services without any reorganization of the Lower 900 MHz Band, making it inappropriate to credit the full economic value of a GPS backup to NextNav’s specific proposal.⁹

In response to the IBTTA Economic Analysis Report, the Brattle Group filed a supplemental report that rested on a central premise: that the cost to unlicensed Part 15 devices of the NextNav proposal would be “approximately zero.”¹⁰ The Brattle Group reached this conclusion by crediting NextNav’s own technical study, which purported to show that 5G operations would not cause unacceptable interference to unlicensed devices and that Part 15 devices could continue operating across the entire band under NextNav’s proposal.¹¹ That conclusion is incorrect.

THE TECHNICAL RECORD REFUTES THE “ZERO COST” PREMISE

The Brattle Supplemental Report’s “zero cost” conclusion depended entirely on NextNav’s assertion that its proposed 5G operations can coexist with Part 15 devices

⁷ See Letter from ACT | The App Association et al. to Marlene H. Dortch, Secretary, FCC, WT Docket No. 24-240, RM-11989 (filed Mar. 10, 2025) <https://www.fcc.gov/ecfs/document/1031068788620/1> (“Coalition Letter”).

⁸ See IBTTA Economic Analysis Report at 1-3.

⁹ See *id.* at 20-28.

¹⁰ Coleman Bazelon & Paroma Sanyal, Brattle Group, *Brattle Second Supplemental Report: Reply to the Harold Furchtgott-Roth Filing* (Jul. 17, 2025) (“Brattle Supplemental Report”) at iv, attached to Letter from Renee Gregory, NextNav Inc., to Marlene H. Dortch, Secretary, FCC, WT Docket Nos. 24-240 and 25-110 (filed July 17, 2025) <https://www.fcc.gov/ecfs/document/1071792861358/1>.

¹¹ See *id.* at vi-vii.



without causing unacceptable interference.¹² That assertion has been contradicted by the weight of the technical evidence in the record.

The LS telcom Study submitted by the RAIN Alliance in January 2026 examined interference in both directions—from NextNav’s proposed system into RAIN RFID, and from RAIN RFID into NextNav’s proposed system—using both statistical Monte Carlo simulation and scenario-specific analysis of real-world RAIN deployments.¹³ The LS telcom Study found that NextNav’s proposed operations and RAIN RFID are effectively incompatible in the same band: RAIN RFID devices would cause severe interference to NextNav’s proposed 5G uplink, while NextNav’s proposed high-power operations would cause localized interference to RAIN RFID systems.¹⁴

The LS telcom Study’s findings are consistent with the conclusions of other independent analyses in the record. The Plum Report found that NextNav’s oversimplified analysis failed to account for the variable and context-dependent deployment of Part 15 devices.¹⁵ The Pericle Coexistence Study similarly concluded that NextNav’s proposed operations would lead to significant levels of harmful interference for both existing users and NextNav’s users.¹⁶ Multiple other stakeholders have also identified critical deficiencies in NextNav’s one-directional and unrealistic interference analysis.¹⁷

¹² John Kim et al., *5G NR and Unlicensed Part 15 Technologies in the Lower 900 MHz Band*, NextNav Inc. (Feb. 27, 2025), attached to Letter from Renee Gregory, NextNav Inc., to Marlene H. Dortch, Secretary, FCC, WT Docket No. 24-240 (Feb. 27, 2025) <https://www.fcc.gov/ecfs/document/102280525327052/1> (“NextNav Study”).

¹³ See RAIN Alliance Technical Report Letter at 5.

¹⁴ See *id.* at 5-6; LS telcom Study at 17, 23-24.

¹⁵ See Richard Rudd, *Assessment of the NextNav Inc document “5G NR and Unlicensed Part 15 Technologies in the Lower 900 MHz Band - A coexistence Analysis,”* (Apr. 25, 2025) (“Plum Report”), attachment to Letter from Aileen Ryan et al., Counsel to RAIN Alliance et al., to Marlene H. Dortch, Secretary, FCC, WT Docket Nos. 25-110 and 24-240 (filed Apr. 28, 2025) <https://www.fcc.gov/ecfs/document/1042817716000/1>.

¹⁶ See Letter from Howard Waltzman, Counsel to the Security Industry Association, to Marlene Dortch, Secretary, FCC, WT Docket Nos. 24-240 and 25-110, at Attachments 2 and 3 (Sept. 12, 2025) <https://www.fcc.gov/ecfs/document/109122414803408/1> (“Pericle Coexistence Study”); Letter from Howard Waltzman, Counsel to the Security Industry Association, to Marlene Dortch, Secretary, FCC, WT Docket Nos. 24-240 and 25-110 (Dec. 9, 2025) <https://www.fcc.gov/ecfs/document/12092538826909/1>.

¹⁷ See, e.g., Letter from The Association for Broadband without Boundaries (“WISPA”), WT Docket Nos. 24-240 and 25-110, at 2-3 (filed Dec. 8, 2025) <https://www.fcc.gov/ecfs/document/120860898385/1>; Letter from the Connected Devices for America Coalition, WT Docket Nos. 24-240 and 25-110, at 5 (filed Sept. 15, 2025) <https://www.fcc.gov/ecfs/document/1091609441588/1>.



Because the Brattle Supplemental Report’s “zero cost” conclusion rested entirely on the assumption of successful coexistence—an assumption that has been contradicted by the technical record—the cost to unlicensed Part 15 devices is not zero. It is, as the RAIN Economic Impact Study now quantifies, in the billions of dollars for RAIN RFID users alone. The Brattle reports also fail to properly account for the substantial costs associated with retrofitting and replacing the installed base of Part 15 devices, including RAIN RFID devices, to operate in the narrower 907-918 MHz sub-band that would remain available under NextNav’s proposal.¹⁸ As technical evidence in the record clearly demonstrates, forcing billions of devices to shift transmissions into a narrower portion of the Lower 900 MHz Band would be prohibitively costly and completely unworkable because the severe congestion would unacceptably degrade existing Part 15 device operations.¹⁹

THE RAIN ECONOMIC IMPACT STUDY: QUANTIFIED DIRECT COSTS

The RAIN Economic Impact Study calculates the direct costs that the NextNav proposal would impose on RAIN RFID users. Drawing on the LS telcom Study’s finding

¹⁸ NextNav has proposed what it calls an “Optimized Band Plan” that would designate 907-918 MHz for LMS, with the remainder of the 902-928 MHz band allocated to 5G. See, e.g., NextNav Licensed Tolling Coexistence Study at slide 3 (Aug. 2025), attached to Letter from NextNav to FCC, WT Docket No. 24-240 (filed Aug. 1, 2025) <https://www.fcc.gov/ecfs/document/10801028019576/1>. NextNav ignores Part 15 devices in its “Optimized Band Plan” and erroneously maintains that Part 15 devices could continue to operate across the full band. Letter from NextNav to FCC, WT Docket Nos. 24-240 and 25-110, at 2 (filed Nov. 24, 2025) <https://www.fcc.gov/ecfs/document/1124286198095/1>. NextNav has not provided any analysis on required guard bands and out-of-band emissions. Technical analysis in the record demonstrates that coexistence between RAIN RFID and NextNav’s proposed 5G operations is not feasible. See LS telcom Study at 4, 24-25. In practice Part 15 users would be forced out of the band entirely. *Id.*

¹⁹ See Reply Comments of Wi-Fi Alliance, WT Docket Nos. 24-240 and 25-110, at 7-8 (filed May 13, 2025) <https://www.fcc.gov/ecfs/document/1051350645876/1>. See also Comments of The Information Technology Industry Council, WT Docket No. 25-110, at 4 (filed Apr. 28, 2025) <https://www.fcc.gov/ecfs/document/104282941420613/1> (describing NextNav’s proposal as “causing severe congestion”); Letter from Mark F. Muriello, Vice President, IBTTA, to Marlene Dortch, Secretary, FCC, WT Docket No. 24-240 and RM-11989, Attach. 1 at 18 (filed Apr. 29, 2025) <https://www.fcc.gov/ecfs/document/1042983929938/2> (explaining performance degradation for Part 15 device operations “due to loss of available bandwidth . . . in the compressed 11 MHz band” proposed by NextNav); RAIN Alliance Technical Report Letter at 6 (NextNav’s proposal would “dramatically increase interference,” for Part 15 device operations and “overcrowd the 11 MHz sub-band,” requiring “significant equipment redesign,” that would be “prohibitively expensive.”); Letter from The Association for Broadband without Boundaries (“WISPA”) at 3, <https://www.fcc.gov/ecfs/document/120860898385/1> (filed Dec. 8, 2025) (“NextNav offers no theory or plan on how millions of devices could be re-tuned or the costs and consequences of devices operating in a smaller portion—only 11 MHz—of the band.”).



that RAIN RFID and 5G mobile or fixed wireless services are incompatible in the same band,²⁰ the study estimates the costs of replacing or retrofitting RAIN RFID readers to operate in NextNav's narrower proposed 907-918 MHz sub-band. The Ad-Hoc RAIN RFID Coalition, in comments and reply comments filed in WT Docket Nos. 24-240 and 25-110, has estimated that NextNav's proposal would "cost billions of dollars to implement,"²¹ and "cost the overall economy many billions more."²² The RAIN Economic Impact Study confirms the magnitude of the economic damage estimated by the Ad-Hoc RAIN RFID Coalition and precisely quantifies the damage in concrete terms.

The study estimates that by 2026, the installed base of RAIN RFID readers in the United States exceeds 1.7 million units.²³ Replacing or retrofitting these devices to operate in the narrower band would require expenditures in three categories: (1) equipment costs to purchase replacement or retuned devices; (2) labor costs to install the new equipment, which industry sources estimate at 300% to 400% of equipment costs; and (3) software modification costs to accommodate the new equipment and narrower spectrum range, estimated at 20% to 100% of equipment costs.²⁴

The total quantified cost to RAIN RFID end users of replacing or retrofitting equipment ranges from \$5.0 billion to \$7.2 billion.²⁵ These figures represent direct costs only and do not account for other substantial harms discussed below.

Moreover, the 907-918 MHz sub-band would not provide a viable long-term home for RAIN RFID operations even if the equipment costs were absorbed. NextNav's proposal does not include guard bands between its proposed full-power 5G operations and the 907-918 MHz sub-band, meaning that the practically usable spectrum would be even narrower than 11 MHz.²⁶ The sub-band would also be shared with many other incumbent users of the Lower 900 MHz Band—including military operations, ISM devices,

²⁰ See LS telecom Study at 3; RAIN Economic Impact Study at 5.

²¹ See Comments of The Ad Hoc RAIN RFID Coalition at 13-15, WT Docket No. 25-110 (filed Apr. 28, 2025) <https://www.fcc.gov/ecfs/document/104280199221611/1>; See also Reply Comments of the Ad Hoc RAIN RFID Coalition at 12-13, WT Docket No. 25-110, (filed May 13, 2025) <https://www.fcc.gov/ecfs/document/1051353407468/1> ("Ad-Hoc Coalition Reply Comments").

²² See Ad-Hoc Coalition Reply Comments at 12.

²³ See RAIN Economic Impact Study at 6-7.

²⁴ See *id.* at 7.

²⁵ See *id.* at 8.

²⁶ See *id.* at 5-6.



licensed Part 90 non-M-LMS devices such as electronic tolling systems, and Part 97 amateur radio operators—that would similarly be compressed from a 26 MHz band into 11 MHz.²⁷ This compression would dramatically increase congestion and interference, compounding the harms to all affected users. For many if not all users, a switch from the 902-928 MHz band to the smaller sub-band would require significant equipment redesign, including hardware changes—not, as NextNav has asserted, mere retuning “at minimal cost.”²⁸

THE RAIN ECONOMIC IMPACT STUDY: INDIRECT COSTS

Beyond the \$5.0-7.2 billion in direct costs, the RAIN Economic Impact Study identifies several categories of indirect economic harm that would result from the NextNav proposal.

Loss of regulatory protections for Part 15 devices. The Lower 900 MHz Band is unique in that Part 15 devices enjoy substantial protection from interference by other users. Under the current rules, M-LMS licensees such as NextNav must “not cause interference to and must tolerate interference from” ISM devices and radiolocation government stations,²⁹ and M-LMS licenses are conditioned on the licensee’s ability to “demonstrate through actual field tests that their systems do not cause unacceptable levels of interference to 47 C.F.R. Part 15 devices.”³⁰ NextNav’s proposal would eliminate these protections³¹—a fundamental change to the regulatory framework that the Commission has maintained through multiple reviews of the LMS rules over the past three

²⁷ See *id.* at 5.

²⁸ See Letter from NextNav to FCC, WT Docket No. 24-240, at 1 (filed Aug. 1, 2025) <https://www.fcc.gov/ecfs/document/10801028019576/1>; cf. Letter from E-ZPass Group and the International Bridge, Tunnel & Turnpike Association at 5 (filed Dec. 5, 2025) <https://www.fcc.gov/ecfs/document/1205065012814/1> (disputing NextNav’s “minimal cost” characterization).

²⁹ 47 C.F.R. § 90.353(a).

³⁰ 47 C.F.R. § 90.353(d); see also *Amendment of Part 90 of the Commission’s Rules to Adopt Regulations for Automatic Vehicle Monitoring Systems*, Memorandum Opinion and Order and Further Notice of Proposed Rule Making, 12 FCC Rcd 13942, 13964 (1997).

³¹ See Letter from NextNav to FCC, WT Docket No. 24-240, at A-4, A-6, and A-11 (June 7, 2024), <https://www.fcc.gov/ecfs/document/10607137757430/1> (proposing to remove, among other provisions, 47 C.F.R. §§ 90.353(d) and 90.361, which condition EA multilateration LMS licenses on the licensee’s ability to demonstrate that their systems do not cause unacceptable interference to Part 15 devices and permit Part 15 operation without the requirement to protect M-LMS operations).



decades.³² NextNav has failed to justify removing protections that Part 15 device users have relied upon since the inception of LMS operations.

No compensation to affected users. Under current rules, NextNav effectively cannot cause unacceptable levels of interference to Part 15 devices and must accept interference from Part 15 devices. The NextNav proposal would redistribute these rights to NextNav's benefit, yet NextNav has not offered compensation to Part 15 device users—including RAIN RFID users—for either the loss of regulatory protections or the actual interference that its operations would cause.³³ Given that M-LMS licenses are conditioned on non-interference and acceptance of interference, NextNav's failure to propose compensation for removing those protections weighs strongly against any rule change that would redistribute rights to NextNav's benefit.

Transition and disruption costs. Replacing or retuning RAIN RFID equipment would not simply be a matter of swapping hardware. Businesses would face significant costs for systems integration, employee retraining, and disruption of ongoing operations.³⁴ These disruptions would be particularly severe in the retail sector, which relies heavily on RAIN RFID for inventory management, and in the logistics sector, where RAIN RFID is integral to supply chain operations.³⁵

Regulatory uncertainty and innovation chilling effects. Developers and users of spectrum rely on regulatory certainty about the bands in which they operate. Altering rules for the Lower 900 MHz Band to the detriment of RAIN RFID technologies as proposed by NextNav would chill investment by both current and prospective developers

³² See RAIN Economic Impact Study at 8-10 (reviewing the history of LMS rules from 1995 through 2010 and noting that the Commission has never altered the initial interference regime for LMS operations).

³³ See *id.* at 10.

³⁴ See *id.* at 10-11; see also Letter from Joseph Brazauskas, Counsel to Avery Dennison, to Marlene Dortch, Secretary, FCC, WT Docket No. 24-240 (filed Nov. 21, 2024) <https://www.fcc.gov/ecfs/document/1121169493706/1>.

³⁵ See RAIN Economic Impact Study at 11; see also Joint Comments of RAIN Alliance Inc. and AIM Inc. at 4, WT Docket No. 24-240 (filed Sept. 5, 2024) <https://www.fcc.gov/ecfs/document/10906412205140/1>; Reply Comments of Avery Dennison Corp., WT Docket No. 24-240, RM-11989 (filed Sept. 20, 2024) <https://www.fcc.gov/ecfs/document/10920116176748/1>.



and users of RAIN RFID technologies.³⁶ Exciting innovations and novel applications for RAIN RFID services would be jeopardized by the NextNav proposal.³⁷

Reduced international coordination. RAIN RFID equipment operates in the 902-928 MHz band in practically every country in the Americas. The NextNav proposal would create spectrum coordination problems, particularly in urbanized border areas with Canada and Mexico.³⁸

Loss of consumer welfare. RAIN RFID devices are used across many competitive markets because they are more efficient and less costly than alternative technologies. If the Commission were to adopt the NextNav proposal, businesses that currently employ RAIN RFID devices would be forced either to purchase replacement equipment at substantial cost or to adopt less efficient alternative technologies—and in either case would be compelled to pass those costs along to consumers.³⁹

THE COSTS TO RAIN RFID USERS ALONE EXCEED ANY PLAUSIBLE BENEFIT OF THE NEXTNAV PROPOSAL

The quantified costs to RAIN RFID users of \$5.0-7.2 billion should be considered in the broader context of the economic record in this proceeding. The IBTTA Economic Analysis Report previously estimated the overall costs of the NextNav proposal—across all users of the Lower 900 MHz Band—at tens of billions of dollars and the benefits at no more than \$1.2-2.1 billion.⁴⁰ A broad coalition of more than 60 industry organizations similarly concluded that the Brattle Group’s analysis fails to demonstrate a positive cost-benefit analysis for the proposal.⁴¹

The RAIN Economic Impact Study adds critical specificity to this picture. The \$5.0-7.2 billion in quantified costs represents the harm to just one category of Part 15 devices—RAIN RFID—among the many that operate in the Lower 900 MHz Band. It does not include costs to electronic tolling operators, ISM device users, amateur radio operators,

³⁶ See RAIN Economic Impact Study at 11.

³⁷ See *id.*; see also, e.g., Impinj Ex Parte Letter at 6-9, WT Docket Nos. 24-240, 25-110 (filed Sept. 17, 2025) <https://www.fcc.gov/ecfs/document/109170133019034/1>.

³⁸ See RAIN Economic Impact Study at 11.

³⁹ See *id.* at 12.

⁴⁰ See IBTTA Economic Analysis Report at 1-3.

⁴¹ See Coalition Letter at 4.



military operations, or the countless other Part 15 devices that share the band. Even without accounting for these additional costs, and even without accounting for the substantial unquantifiable harms described above, the costs to RAIN RFID users alone approach or exceed the most generous estimates of the benefits of the NextNav proposal.

As Dr. Furchtgott-Roth concludes: the quantifiable costs and the unquantifiable harms to the RAIN RFID industry and related consumers are far greater than any plausible benefit of the NextNav proposal.⁴² Taking into account the costs and harms to the other current users of the Lower 900 MHz Band makes the comparison even more one-sided.⁴³

CONCLUSION

The RAIN Alliance urges the Commission to:

Deny NextNav’s Petition for Rulemaking in WT Docket No. 24-240. The technical record demonstrates that NextNav’s proposed operations cannot coexist with authorized Part 15 devices in the 902-928 MHz band, and the economic record now confirms that the costs of the proposal—to RAIN RFID users alone—would be measured in the billions of dollars, far exceeding any plausible benefits.

Continue the evidence-based evaluation in WT Docket No. 25-110 to identify GPS-complementary PNT technologies that can strengthen national resilience without compromising existing, mission-critical infrastructure.

The United States must—and can—build a robust GPS backup system, without endangering the technologies that already safeguard our economy, consumers, and national defense.

Respectfully submitted,

/s/ Aileen Ryan

Aileen Ryan

⁴² See RAIN Economic Impact Study at 4.

⁴³ See *id.*



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September 12, 2025

VIA ECFS

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street NE
Washington, DC 20554

**Re: Wireless Telecommunications Bureau and Office of Engineering and Technology
Seek Comment on NextNav Petition for Rulemaking (WT Docket No. 24-240);
Promoting the Development of Positioning, Navigation, and Timing Technologies
and Solutions (WT Docket No. 25-110)**

Dear Ms. Dortch:

On September 11, 2025, representatives of the Security Industry Association (“SIA”), along with SIA’s counsel, met with staff from the Commission’s Wireless Telecommunications Bureau (“WTB”) and the Office of Engineering and Technology (“OET”) to discuss the above-referenced proceedings. Attendees in the meeting are listed in Attachment 1.

SIA’s attendees discussed the attached technical coexistence study, *Radio Coexistence Study Between Lower 900 MHz Incumbents and Potential 5G Network*, and presentation, both conducted by Pericle Communications Company (“Pericle”). Pericle is an engineering consulting firm that specializes in wireless communications, and, as described in the study, has extensive experience with coexistence proposals.

As the Pericle study details, NextNav Inc.’s (“NextNav”) proposed 5G cellular network and reallocation of the 902-928 MHz Band (the “Lower 900 MHz Band”) described in its Petition for Rulemaking¹ would be detrimental to the billions of unlicensed Part 15 devices that currently operate in the band. These devices span a range of uses, including public safety, home automation, wireless internet service providers (“WISPs”), security, access control, and meter

¹ *NextNav Petition for Rulemaking, Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz)*, WT Docket No. 24-240 (filed Apr. 16, 2024).

reading. In particular, incumbent unlicensed Part 15 devices utilizing the Lower 900 MHz Band include fire and carbon monoxide alarms, panic buttons, flood sensors, motion sensors, and a range of other life-saving devices – and these devices are used across millions of homes, businesses, and government buildings, as well as rural, suburban, and urban environments.

The propagation modeling and Monte Carlo simulations employed in the Pericle study demonstrate that these devices and NextNav’s proposed network simply cannot co-exist. The deterioration in receiver sensitivity that would result from NextNav’s network, as well as ensuing co-channel and adjacent channel interference, would be so drastic as to make the band unusable for incumbent unlicensed devices, including the ubiquitous public safety devices described above. By way of example, the study finds that outdoor unlicensed Part 15 devices using a 200 kHz bandwidth in the Lower 900 MHz Band would need a signal to be, at a minimum, 538 times greater in order to overcome the interference from the NextNav network — effectively rendering these devices inoperable. Devices using larger bandwidths would experience even greater degradation of sensitivity.

The study’s simulations demonstrate that wireless cameras and similar unlicensed incumbent Part 15 devices will experience interference and blocking from NextNav’s proposed network more than 60% of the time, even at a coverage radius of 2.0 km. Of course, at smaller coverage radii, the likelihood of interference is even greater – effectively stripping the devices of all utility. NextNav itself seems to acknowledge that its proposed network will create this interference, as it has sought “the removal of the current requirement that [NextNav] not cause unacceptable levels of interference to Part 15 devices.”² NextNav’s proposal would also go so far as to require Part 15 devices to shut down if they cause harmful interference to NextNav’s devices.³ Due to the decentralized nature of these devices and the fact that the majority of them are customer-controlled, such a shutdown would be impossible in practice, further evidencing the technical impracticability of NextNav’s proposal.

As the records in these proceedings demonstrate, NextNav’s proposed network would have devastating consequences for the myriad existing unlicensed users of the Lower 900 MHz Band, including the public safety devices on which millions rely on a daily basis for life-saving communications. The Pericle study provides specific, technical details regarding these impacts.

Pursuant to Section 1.1206 of the Commission’s rules, a copy of this letter has been submitted in the record of the above-referenced proceedings, and a copy of this letter has been provided to the meeting participants. If there are any questions regarding the foregoing, please contact the undersigned.

² *Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking*, Public Notice at 4, DA 24-776 (rel. Aug. 6, 2024) (“Public Notice”).

³ See Letter from Robert Lantz, NextNav, Inc., to Marlene Dortch, Secretary, FCC, WT Docket No. 24-240 (June 7, 2024) at A-6 (removing the limitation on interference from Part 15 devices to M-LMS systems) and A-11 (adding a requirement that Part 15 devices not cause harmful interference and accept harmful interference from TPNT devices in the Lower 900 MHz Band).

Sincerely,



Howard W. Waltzman
Counsel to the Security Industry Association

cc: WTB and OET Attendees

Attachment 1: List of Attendees

Attachment 2: Pericle Presentation

Attachment 3: Pericle Study

Attachment 1

List of Attendees

Michael McGinley, Pericle Communications Company

Jacob Parker, Security Industry Association

Howard Waltzman, Mayer Brown

Michael Lewis, DLA Piper, on behalf of Motorola Solutions

Chris Young, Johnson Controls

Bobby Parmiter, Amazon

John Lockwood, Barbara Esbin, Linda Chang, Tom Derenge, Andrew McArdell, Kamran Etemad, and Melissa Conway, Wireless Telecommunications Bureau

Michael Ha, Jamison Prime, Nicholas Oros, Bahman Badipour, and Aole Wilkinsel, Office of Engineering and Technology

Attachment 2



900 MHz Part 15 Devices and 5G Coexistence Study

Michael McGinley
Senior Systems Engineer
mnmcginley@pericle.com
(719) 684-4195

September 11, 2025

About Pericle Communications Company

- Founded in 1992
- Major Contributor in 800 MHz Public Safety Rebanding
 - Sprint and Nextel Interleaved Channels
- Major Contributor in 900 MHz 3x3 and 5x5 LTE Broadband Effort
 - Moving from narrowband channels to a contiguous broadband channel
- Over 15 years of experience in interference to LTE systems
- Over 30 years of experience in interference to LMR systems
- Contributor to the Telecommunications Industry Association (TIA) Strong Signal Interference Procedure and Thresholds

Current Part 15 900 MHz Environment

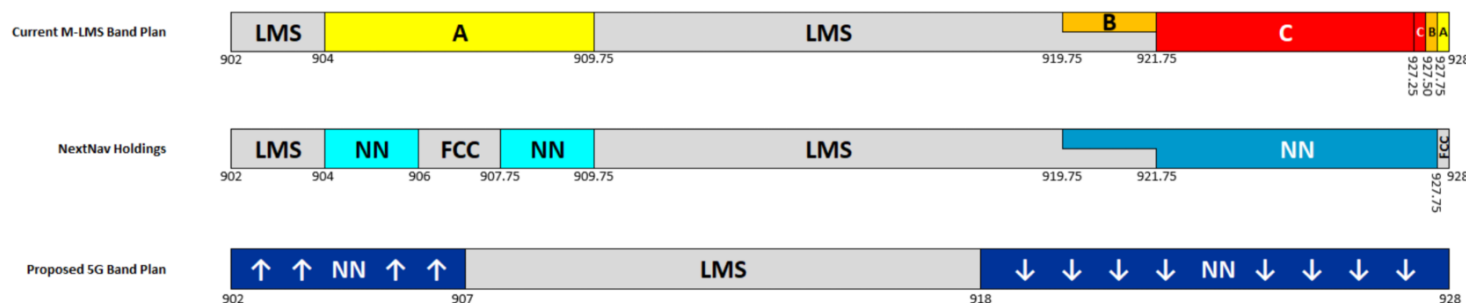
- Spectrum from 902-928 MHz.
- Allows for the use of unlicensed devices, such as motion sensors, RFID readers, RFID access, carbon monoxide detectors, flood sensors, security cameras, wireless mics, and thousands of other use cases.
- Unlicensed devices must follow FCC rules for the band.
 - These rules include said devices using frequency hopping spread spectrum technology.
 - Devices are also limited by the amount of power at which they can transmit. This is 1 watt with a 6 dBi gain antenna; however, a majority of devices radiate well below this power level.
- Unlicensed devices must accept interference from licensees and generally are prohibited from interfering with the licensees.
- Current licensees are Multilateration Location and Monitoring Services
 - These services were developed in the 1990s, and a majority went out of business.
 - NextNav (formerly Progeny and the last M-LMS licensee) claims to have built a network in San Francisco that went on air in 2012 and consisted of 34 sites. There is no mention of how many users.

Part 15 Devices



NextNav Proposed 900 MHz Environment

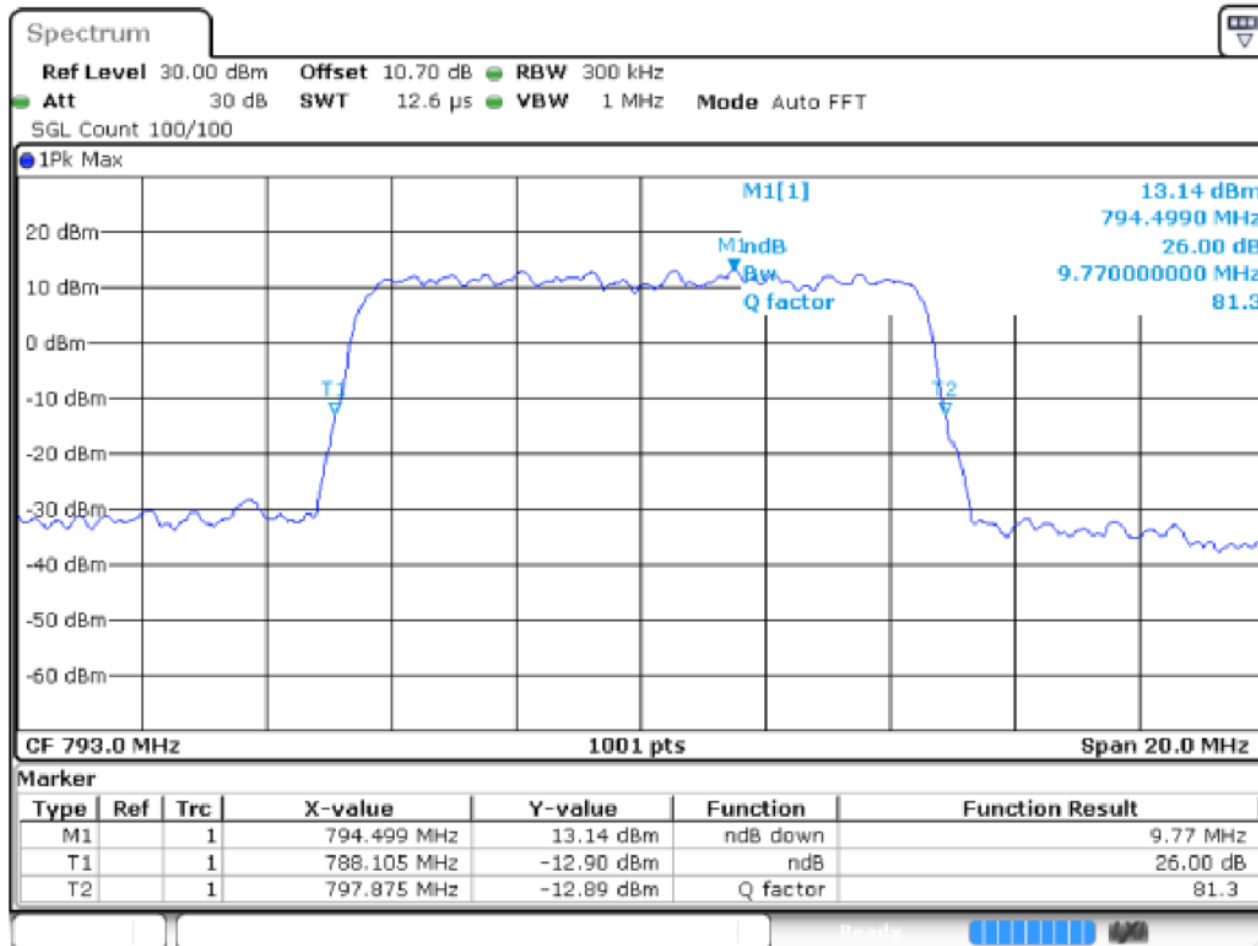
- NextNav proposes a 5G channel with the uplink at the bottom of the band, 902-907 MHz, and the downlink at the top, 918-928 MHz.
- The NextNav Technical Study states that its network can coexist with Part 15 devices.
 - A large part of the NextNav study is comparing the potential interference from a M-LMS network to a 5G network.



Proposed NextNav 5G Channel(s) Basic Overview

- The proposed network would be comprised of two channels:
 - 5 MHz Uplink (phone to cell site)
 - 10 MHz Downlink (cell site to phone)
- The proposed downlink would transmit at roughly 4,000 watts.
 - Current unlicensed Part 15 devices are limited to 2.5 watts.
 - The large power difference will result in a severe reduction in range of current Part 15 devices.
- Not only is there power within the channel, but there are out-of-band emissions (OOBE).
- These are limited by the FCC but still significant in an environment where no powerful 5G channel previously existed.
- The NextNav network is also very susceptible to interference.

5G Channels Example



Interference to NextNav

- While NextNav has examined and modeled interference to unlicensed Part 15 devices, it has yet to mention how its network would deal with interference from Part 15 devices.
- The Wi-Fi alliance has stated that there are billions of these devices in the US.
- A majority of these have what is called a “heartbeat.” This heartbeat is a transmission to the hub that gives the status of the device.
- Taking very conservative estimates of the amount of Part 15 devices and large intervals in heartbeats, there would be roughly 50 occurrences of interference to a single NextNav cell site.

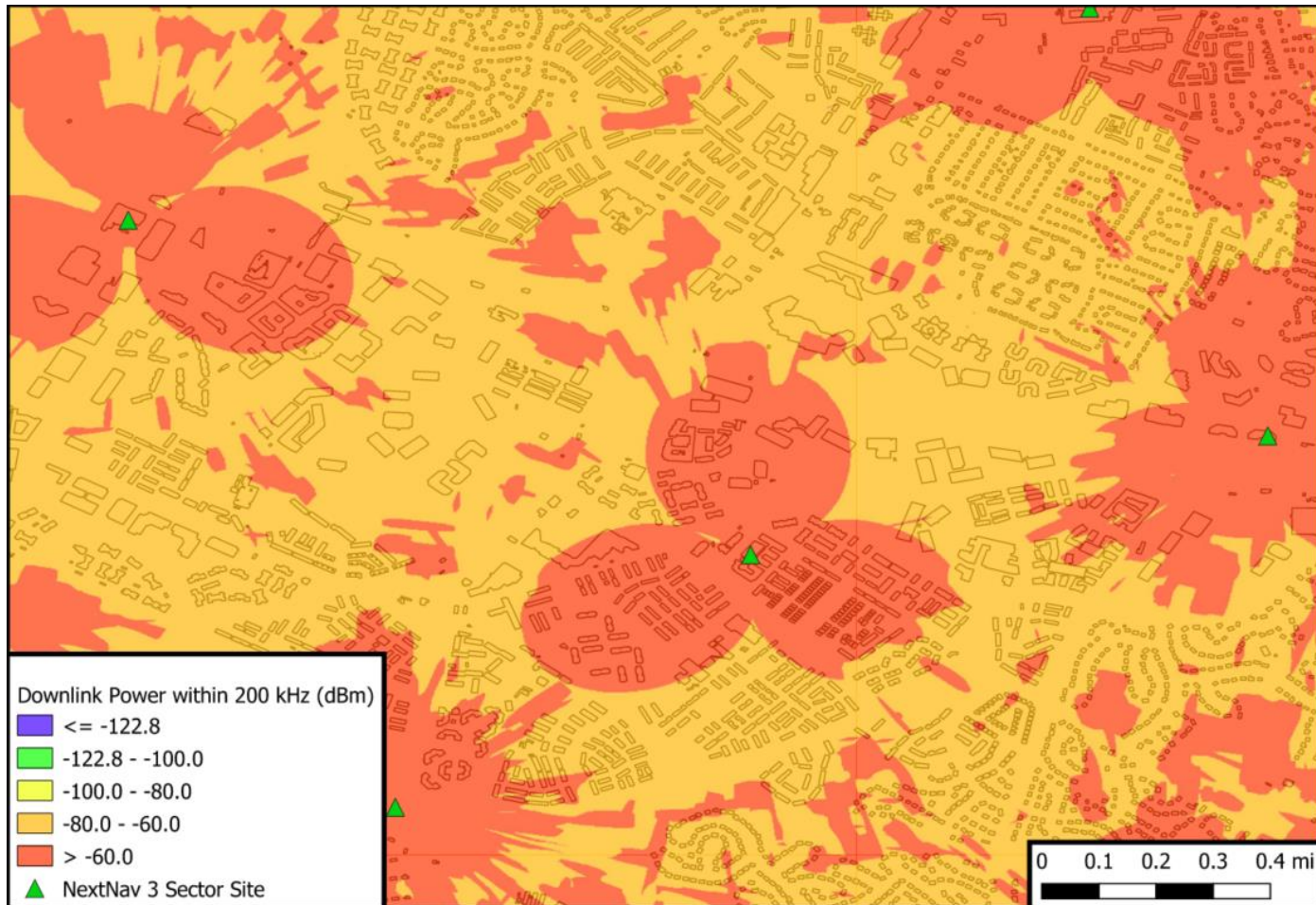
Pericle Coexistence Modeling

- Two types of modeling used
 - Wide area coverage modeling of real-world area
 - Monte Carlo Simulations
- Focus of the modeling was to bound the effects of the proposed 5G network on unlicensed Part 15 devices.
 - When performing any interference modeling, the upper bound should always be the most important case considered.
- Pericle and many other RF engineering companies consider the technical study done by NextNav to be lacking in terms of focusing on anything other than the extreme lower bound of interference modeling.

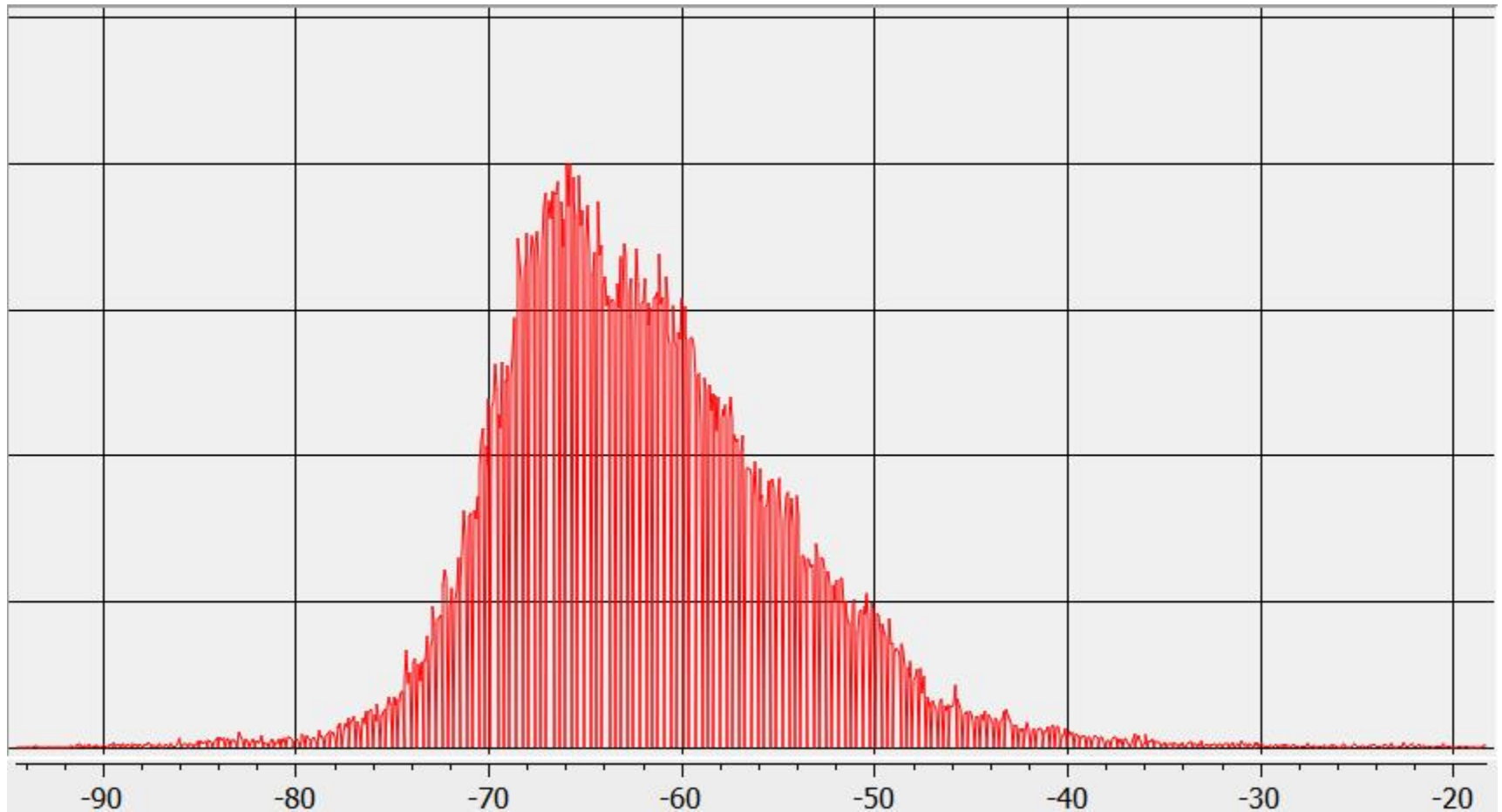
Types of Devices Analyzed

- Three different bandwidths were examined to view the impact on different types of unlicensed Part 15 devices, including the fractional power of the broadband 5G channel within the victim receiver.
- 200 kHz – Representing low-throughput devices, such as panic buttons, motion sensors, and carbon monoxide alarms. These devices are critical to life safety and security across industries and environments.
- 500 kHz – Representing medium-throughput devices, such as wireless microphones, headsets, and license-free two-way radios. First responders use these devices when responding to emergencies.
- 2 MHz – Representing high-throughput devices, such as wireless security cameras and doorbell cameras. Rather than being a narrowband single channel, the 2 MHz bandwidth represents the smallest bandwidth of an 802.11ah channel (also known as WiFi HaLow technology) with the largest bandwidth supported being 8 MHz. Some WISPs currently utilize 8 MHz to provide backhaul to subscribers.

200 kHz Outdoor Modeling



200 kHz Outdoor Modeling Histogram



200 kHz Outdoor Model Analysis

- The 200 kHz reflects a generic receiver that supports devices that include carbon monoxide detectors, panic buttons, motion detectors, and a host of other devices.
- In an interference-free environment, the sensitivity of this radio is -105 dBm.
- In the scenario shown above, this sensitivity is reduced in a range to a best case scenario of -68 dBm.
- This specific modeling only addresses adjacent channel cases and does not reflect blocking or adjacent channel interference.

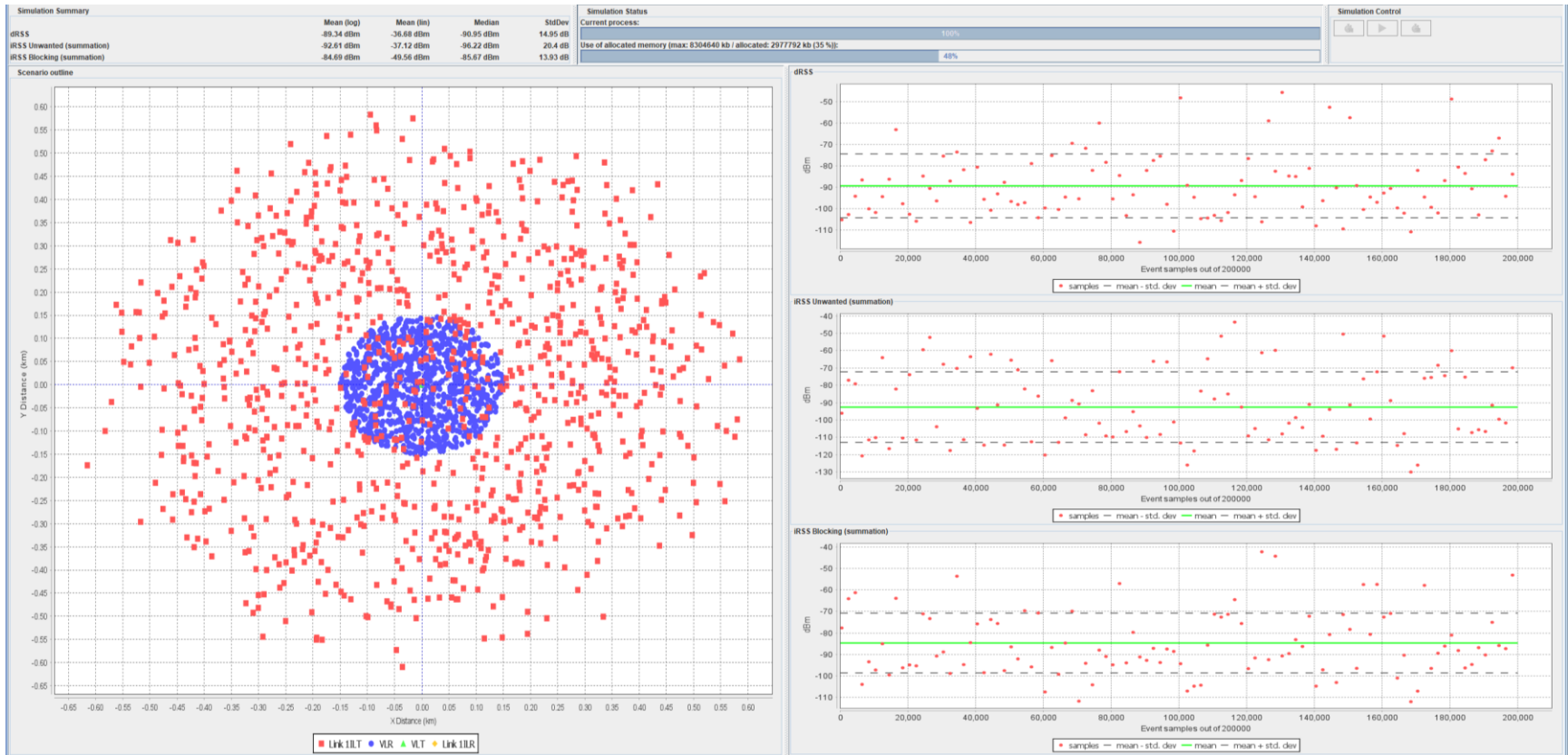
MODELING HISTOGRAM STATISTICS

Victim Receiver Bandwidth	Minimum NextNav Channel Power (dBm)	Maximum NextNav Channel Power (dBm)	Mean NextNav Channel Power (dBm)
200 kHz	-77.7	-16.3	-61.8
500 kHz	-73.7	-12.3	-57.8
2 MHz	-67.7	-6.3	-51.8

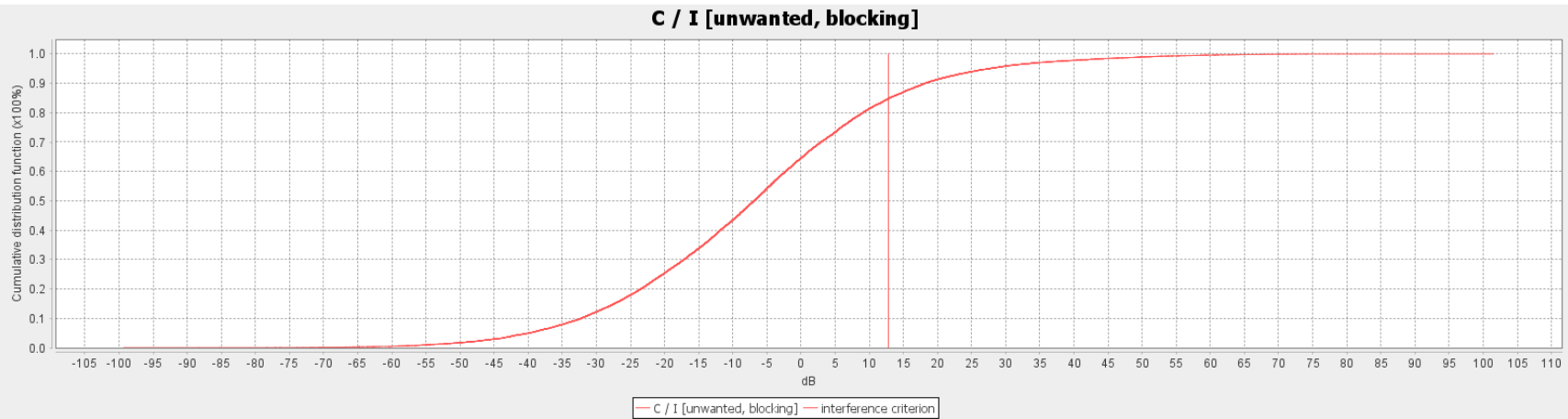
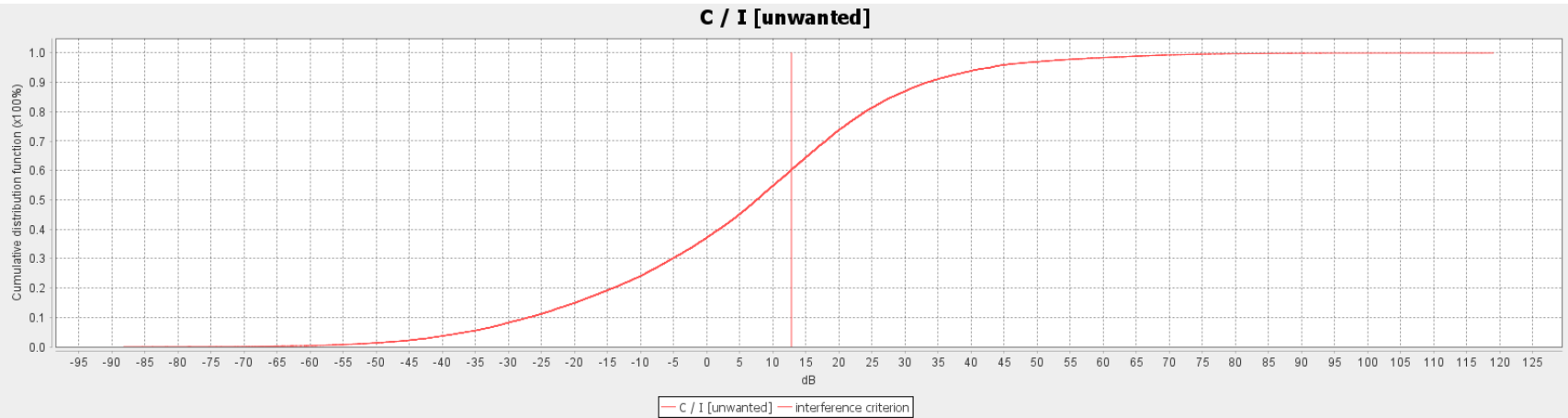
Pericle Monte Carlo Simulations

- Takes receiver blocking and adjacent channel interference into account.
- Uses an indoor pathloss model for Part 15 devices.
- Simulation is built to have a mean value well within the sensitivity of the radio but close to the edge of coverage.
- Victim receiver built using member-supplied data.
- 3GPP emission mask applied to NextNav channel.

Pericle Monte Carlo Simulations 130/200 kHz



Pericle Monte Carlo Simulations 130/200 kHz



PROBABILITY OF INTERFERENCE FROM MONTE CARLO SIMULATIONS

NextNav Coverage Radius (km)	900 Narrowband	Wireless Mic	Wireless Camera (802.11ah 2 MHz channel)
2.0	22.6%	25.9%	29.4%
1.5	27.7%	29.9%	34.6%
1.0	37.0%	36.7%	41.2%
0.5	60.0%	52.4%	57.0%

PROBABILITY OF INTERFERENCE AND BLOCKING FROM MONTE CARLO SIMULATIONS

NextNav Coverage Radius (km)	900 Narrowband	Wireless Mic	Wireless Camera (802.11ah 2 MHz channel)
2.0	41.8%	31.0%	60.3%
1.5	52.6%	37.5%	70.4%
1.0	66.7%	48.2%	82.0%
0.5	84.7%	67.4%	93.8%

Other Issues

- Intercell interference necessary for trilateration
 - NextNav states that it will mute time slots at base stations so as not to cause interference, but that does not change the overall intercell interference issue. This intercell interference will lead to an inefficient design and inefficient use of spectrum.
- No cellular carrier would accept the amount of uplink and downlink interference that will be present in the spectrum.
- Any building requiring a DAS would be off the board for trilateration unless a small cell was used to isolate signals to small areas. Regardless, NextNav's accuracy claim of 20m (which needs to be verified) would be impossible.
- Disparate network topologies
 - Low power short range narrowband vs. wide area high power broadband.

Conclusions

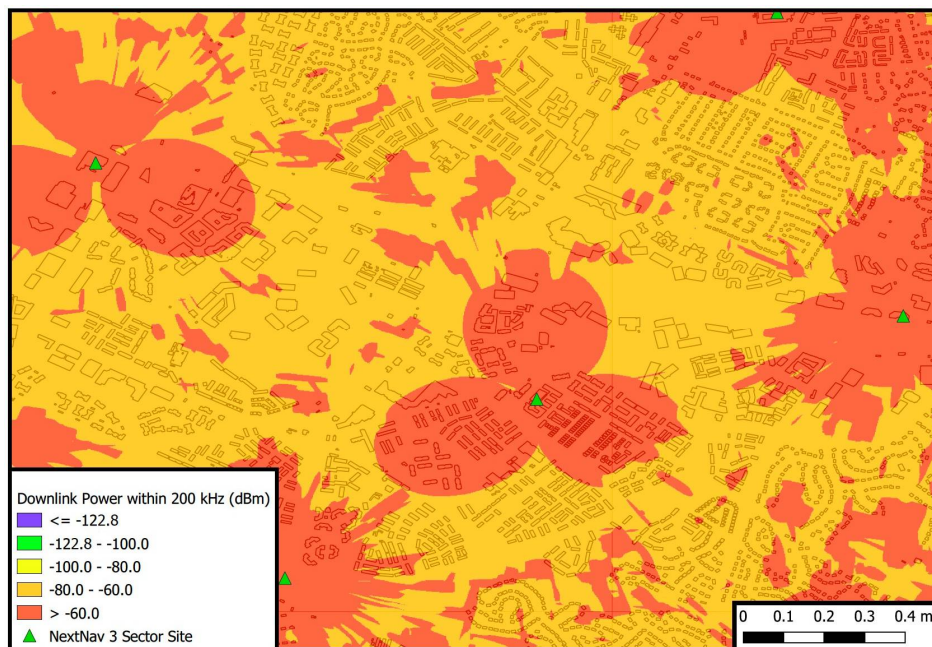
- The proposed NextNav network would cause intolerable interference to existing unlicensed Part 15 devices, many of which are critical to public safety, such as panic buttons, carbon monoxide detectors, fire alarms, wireless microphones used by firefighters, and security cameras.
- The proposed NextNav network, in turn, would experience intolerable amounts of interference in the form of existing Part 15 devices and intercell interference from itself.
- No previous rebanding petition has proposed two device types and network topologies to share spectrum without any sort of frequency coordination. This sharing of spectrum would cause the proposed spectrum swaths to become useless to both the 5G operator and to existing Part 15 devices.

Questions



Attachment 3

Radio Coexistence Study Between Lower 900 MHz Incumbents and Potential 5G Network



September 9, 2025



For Security Industry Association

Mr. Don Erickson, CEO
8455 Colesville Road, Suite 1200
Silver Spring, MD 20910



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Executive Summary

This report provides an independent assessment, conducted by Pericle Communications Company (“Pericle”)¹ for the Security Industry Association, of the feasibility of coexistence between incumbent unlicensed Part 15 radios operating within the 902-928 MHz Band (the “Lower 900 MHz Band”) and the proposed 5G cellular network described in a Petition for Rulemaking submitted by NextNav Inc. (“NextNav”).² Currently, the Lower 900 MHz Band is utilized by billions of unlicensed devices and millions of users across a range of industries, including: public safety, home automation, wireless internet service providers (“WISPs”), security, access control, toll collections, and meter reading. Incumbent Part 15 devices that utilize the band include fire and carbon monoxide alarms, panic buttons, flood sensors, motion sensors, and a range of other life-saving devices. These devices pervade homes, businesses, and government buildings, as well as rural, suburban, and urban environments.

As described in the NextNav Petition, NextNav’s proposal would dramatically alter usage of the Lower 900 MHz Band by providing NextNav with a nationwide license for a 5G cellular network with “a 10-megahertz downlink paired with a 5-megahertz uplink consistent with standard 5G channel sizes.”³ As a result, nearly 60% of the band would be allocated for primary usage by NextNav. NextNav’s proposal also seeks “the removal of the current requirement that [NextNav] not cause unacceptable levels of interference to Part 15 devices.”⁴ In addition, NextNav’s proposal would require unlicensed Part 15 devices to shut down if they cause harmful interference to NextNav’s system.⁵

Today, billions of Part 15 radios co-exist in the Lower 900 MHz Band without coordination by employing spread spectrum modulation (mostly frequency hopping) and other technologies and because of the relatively low power generated by these devices. The NextNav proposal, however, would effectively take away 15 of the available 26 megahertz from these radios, forcing these devices to operate in the remaining 11 megahertz of spectrum in the band. And, in addition to precluding Part 15 devices from working on the channels NextNav wants set aside for its uplink and downlink, the adjacent channel interference caused by out-of-band emissions from NextNav’s proposed system would impose harmful interference on unlicensed Part 15 devices attempting to communicate on the remaining portion of the Lower 900 MHz Band.

¹ Pericle is an engineering consulting firm specializing in wireless communications. The company was a major contributor to the nationwide 800 MHz land mobile radio rebanding project between public safety licensees and Sprint/Nextel. The company also contributed significantly to the recent upper 900 MHz, 3x3 MHz broadband effort initiated by Anterix.

² *NextNav Petition for Rulemaking, Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz)*, WT Docket No. 24-240 (filed Apr. 16, 2024) (“NextNav Petition”).

³ *Id.* at 28 (internal citations omitted).

⁴ *Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking*, Public Notice at 4, DA 24-776 (rel. Aug. 6, 2024) (“Public Notice”).

⁵ See Letter from Robert Lantz, NextNav, Inc., to Marlene Dortch, Secretary, FCC, WT Docket No. 24-240 (June 7, 2024) at A-6 (removing the limitation on interference from Part 15 devices to M-LMS systems) and A-11 (adding a requirement that Part 15 devices not cause harmful interference and accept harmful interference from TPNT devices in the Lower 900 MHz Band).

As further detailed in this report, the NextNav proposal is untenable for existing unlicensed users of the Lower 900 MHz Band. Our analysis, which includes propagation modeling for unlicensed Part 15 devices operating outdoors and Monte Carlo simulations for such devices operating indoors, directly contradicts NextNav's statement that "introducing 5G operations will not cause unacceptable levels of interference to unlicensed devices in the lower 900 MHz band."⁶ If NextNav's proposed network is implemented, receiver sensitivity would significantly deteriorate, and both co-channel and adjacent channel interference would be so drastic as to make the Lower 900 MHz Band unusable for most devices in large parts of the service area. Additionally, 5G networks, such as the one proposed by NextNav, are not designed to operate in the presence of co-channel interference, and coordination is simply not practical with the billions of Part 15 radios that, as a general rule, transmit without the prior knowledge of other users. Thus, we find that the billions of Part 15 devices currently operating in the Lower 900 MHz Band and NextNav's proposed system cannot coexist in any practical way and that significant levels of harmful interference and degraded link quality will occur for both existing users and NextNav's users.

1.0 Notional 5G Network Modeling

In order to evaluate NextNav's proposed network and the effects on incumbent unlicensed devices in the band, Pericle built a notional 5G network in the same geographical area used by NextNav in the NextNav Technical Analysis.⁷ This notional network was based on standard 5G network assumptions and shares a majority of the same parameters that were used by the NextNav Technical Analysis.⁸

It is important to note that NextNav's June 12, 2025 submission states that its positioning, navigation, and timing ("PNT") services will utilize multi-lateration techniques to derive the x,y positions of users, which NextNav asserts would allow its service to provide increased accuracy indoors.⁹ However, in order for this technique to be successful, all parts of the NextNav service area would need to have coverage from at least three separate cell sites. As described in the NextNav Technical Analysis, it does not appear that the notional network that NextNav proposes actually has adequate coverage from three distinct cells to provide the described PNT services.¹⁰ Indeed, the NextNav Technical Analysis fails to identify a single 5G site location served by three distinct cell sites, negating NextNav's claims about the interference effects of its network.

Thus, the following maps and figures represent a notional 5G network that could feasibly provide indoor PNT services and demonstrate the amount of interference that unlicensed 900 MHz devices would experience from this network.¹¹ Three different bandwidths were examined

⁶ *Ex parte* letter from Renee Gregory, NextNav Inc., to Marlene Dortch, Secretary, FCC, WT Docket No. 24-240 (Feb. 27, 2025) ("NextNav Technical Analysis").

⁷ See NextNav Technical Analysis at Sec. 1.4.

⁸ A complete set of parameters and assumptions can be found in Appendix A.

⁹ *Ex parte* letter from Renee Gregory, NextNav Inc., to Marlene Dortch, Secretary, FCC, WT Docket No. 24-240, WT Docket No. 25-110 (June 12, 2025).

¹⁰ NextNav Technical Study at Sec. 2.4. 5G cell locations have been omitted from NextNav's heatmap.

¹¹ For this analysis, Pericle utilized **EDX Signal Pro** with current USGS digital elevation models and clutter data, using TSB-88 loss values.

in order to demonstrate the impact on different types of Part 15 devices, including the fractional power of the broadband 5G channel within the victim receiver. These bandwidths are:

- 200 kHz – Representing low-throughput devices, such as panic buttons, motion sensors, and carbon monoxide alarms. These devices are critical to life safety and security across industries and environments.
- 500 kHz – Representing medium-throughput devices, such as wireless microphones, headsets, and license-free two-way radios.¹² First responders and other safety/security personnel currently utilize these devices when responding to emergencies.
- 2 MHz – Representing high-throughput devices, such as wireless security cameras and doorbell cameras. Rather than being a narrowband single channel, the 2 MHz bandwidth represents the smallest bandwidth of an 802.11ah channel (also known as WiFi HaLow technology) with the largest bandwidth supported being 8 MHz. Some WISPs currently utilize 8 MHz to provide backhaul to subscribers.

¹² See, e.g., Setcom LiberatorMAX Wireless Headset, <https://setcomcorp.com/products/headsets/liberatormax-fire/>; Motorola Solutions DTR700 digital on-site two-way radio, https://www.motorolasolutions.com/en_us/products/two-way-radios/commercial-business-two-way-radio-systems/on-site-business-radios/dtr700.html.

Modeling Results

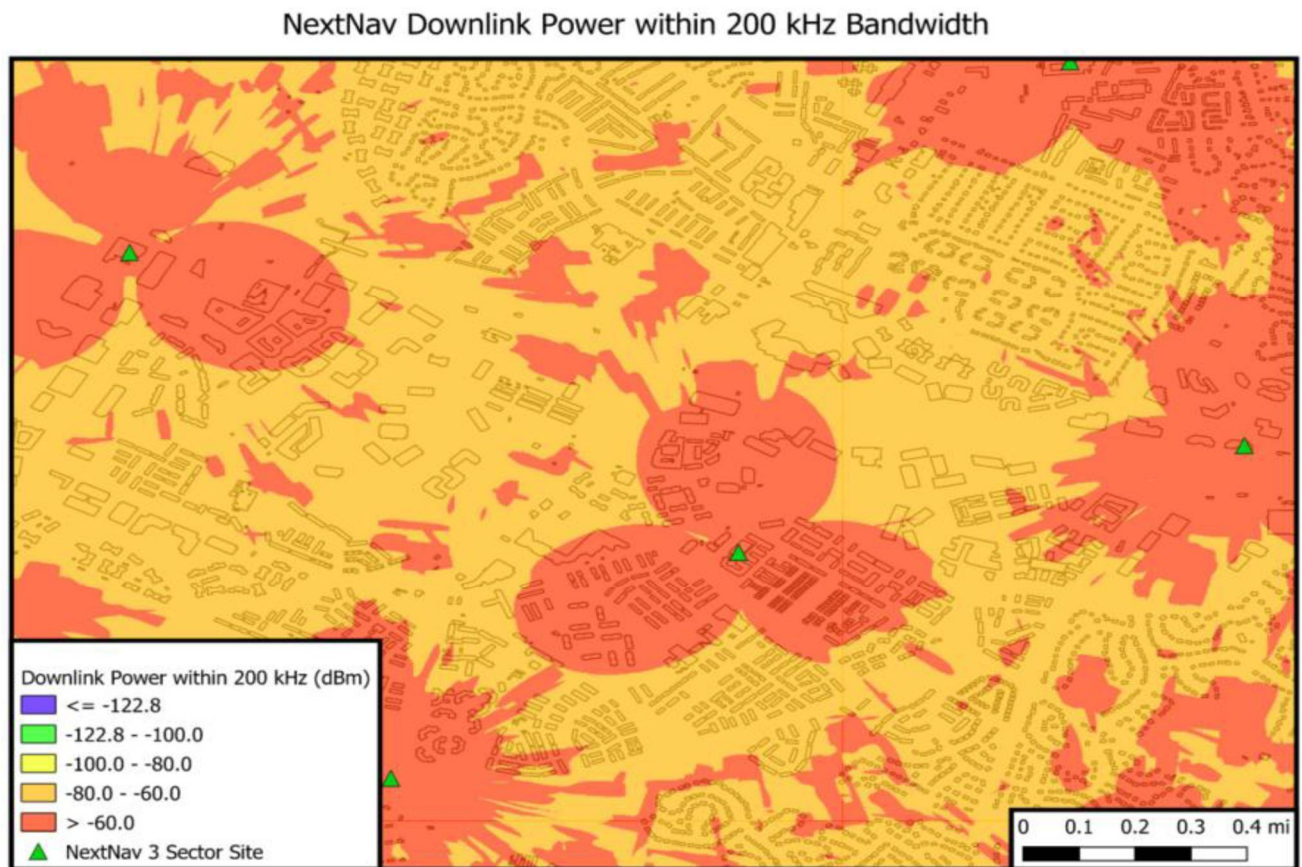


Figure 1 – NextNav Downlink Power within a 200 kHz Bandwidth

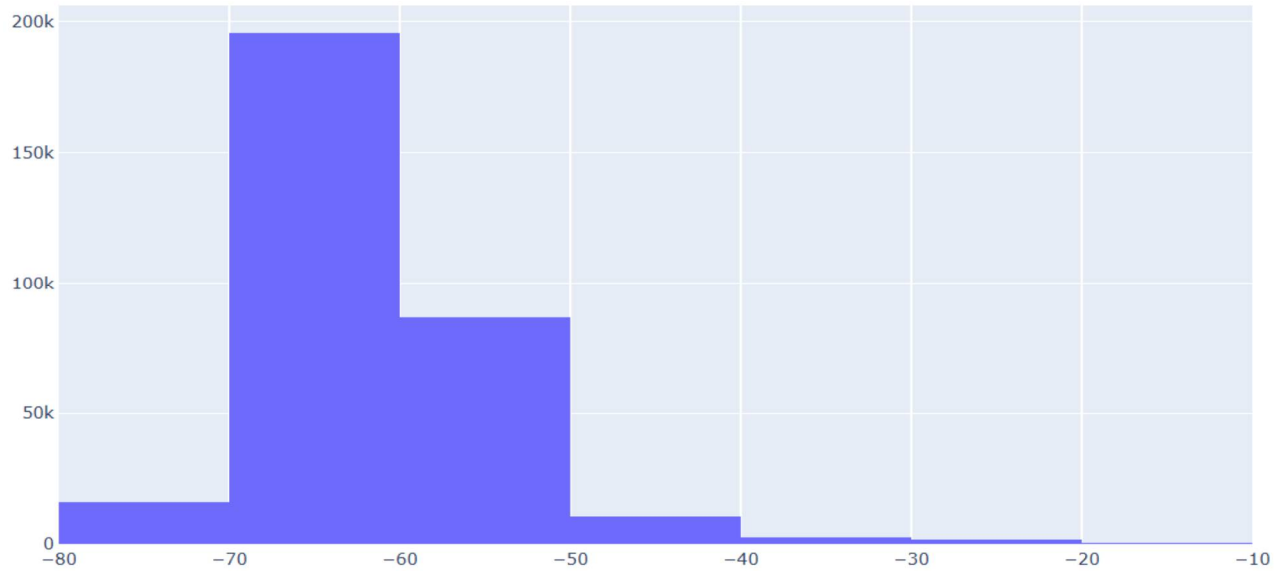


Figure 2 - Histogram of NextNav Downlink Power within a 200 kHz Bandwidth inside a 10 mi² Study Area

Figures 1 and 2 reflect the amount of interference created by the NextNav downlink.¹³ This amount of interference will severely limit the range of devices operating within this spectrum.

Receiver sensitivity is a measure of the minimum signal power that a receiver can detect and still function. Generally speaking, a lower sensitivity allows receipt of weaker signals. Table 1 below shows the minimum, maximum, and mean values for sensitivity for each of the three victim receiver bandwidths. While the 200 kHz analysis can be considered the best case scenario in terms of interference to existing unlicensed devices, even these results are devastating to the types of devices we analyzed.

Victim Receiver Bandwidth	Minimum NextNav Channel Power (dBm)	Maximum NextNav Channel Power (dBm)	Mean NextNav Channel Power (dBm)
200 kHz	-77.7	-16.3	-61.8
500 kHz	-73.7	-12.3	-57.8
2 MHz	-67.7	-6.3	-51.8

Table 1 – Modeling Histogram Statistics

¹³ Similar figures for additional bandwidths are found in Appendix B.

As shown in Table 1, the 200 kHz analysis provides a minimum value of -77.7 dBm, a maximum value of -16.3 dBm, and a mean value of -61.8 dBm. The generic 900 MHz device that the 200 kHz analysis represents has a stated sensitivity of -105 dBm, meaning that the sensitivity is reduced by a minimum of 27.3 dB and a maximum of 88.7 dB. As a result, such a device's signal would need to be a minimum of 538 times greater, and a maximum of 741 million times greater, in order to overcome this interference. Of course, this is simply not possible, and these devices would effectively be rendered inoperable – and, as noted, the 200 kHz bandwidth experiences the least interference of the three selected bandwidths.

This study is focused on outdoor coverage, and it is important to note that a good number of public safety devices exist solely in an outdoor environment. Looking at the mean values for each victim receiver, it can be concluded that the downlink channel spectrum will become unusable by any unlicensed device currently operating in the Lower 900 MHz Band.

The results would be devastating to outdoor public safety devices, including gunshot detection,¹⁴ traffic signal preemption,¹⁵ and vehicle status and alerting devices.¹⁶ Many other 900 MHz Part 15 devices also operate outdoors, including security cameras, traffic control and tolling devices, garage door openers, and others. Additionally, the typical architecture of an indoor security system includes an outdoor keypad hub located near the entrance with various sensors located throughout the building, including outside the building.

A notional home security system can be seen below in Figure 3. The keypad/hub device can be seen near the front door with a series of sensors located on the perimeter of the house, including panic buttons, security cameras, motion sensors, and smoke detectors.

¹⁴ See, e.g., Shooter Detection Systems, go.shooterdetectionsystems.com/1/954823/2024-10-07/h8bcq/954823/1728318597HFvH73sh/SDS_SpecSheet_202410.pdf. Pericle understands that, while Shooter Detection Systems does not provide a publicly available link to its outdoor product, the specifications of the two products are substantially similar, and the outdoor product operates in the Lower 900 MHz Band.

¹⁵ See, e.g., Imagine Industrial Controls.com, <https://imagineindustrialcontrols.com/products/industrial-900-mhz-wireless-remote-control-switch-transmitter-control-receiver>.

¹⁶ See EMTRAC, <https://www.emtracsystems.com/products/vehicle-equipment/>; TAPCO, <https://www.tapconet.com/product/emergency-vehicle-warning-system> (900 MHz Emergency Vehicle Warning Systems).



Figure 3 – Notional Home Security Layout

Each of these devices connects to a hub and relies on the Lower 900 MHz Band for functionality. Under the NextNav proposal, each of these devices will experience the significant sensitivity and signal deterioration described above, interrupting crucial security functionality and rendering the home security devices effectively inoperable.

2.0 Monte Carlo Simulations

Pericle performed Monte Carlo simulations using a Spectrum Engineering Advanced Monte Carlo Analysis Tool (SEAMCAT) to analyze the probability of interference between wireless networks. The goal of Pericle's simulations was to accurately reflect a NextNav downlink while building an unlicensed 900 MHz device network that is receiving well above device sensitivities, thus reflecting an unlicensed network that is functional and within device parameters. The same three device bandwidths utilized for outdoor modeling were also used in the indoor simulations. In each simulation, the actual channels of the device were used, while only downlink interference was considered. The channels of some devices spanned a majority of the Lower 900 MHz Band

spectrum, while some devices were limited to certain channels, according to the data received from manufacturers. The goal of using the actual channels is not only to simulate co-channel interference, but also adjacent channel interference based on the out-of-band emissions of a 5G base station.¹⁷

This adjacent channel interference is vitally important to evaluate. The heart of NextNav's proposal is to effectively reduce the available bandwidth for incumbent devices in the Lower 900 MHz Band to 40% of what is currently available. And, crucially, NextNav proposes to eliminate the existing requirement that it not cause harmful interference to devices even in that remaining spectrum. Based upon our analysis, it is clear that adjacent channel interference will occur, and the information below demonstrates just how drastic the problem will be.

Simulation Results

Simulations were run using 5G base station coverage radii of 0.5 km, 1km, 1.5km, and 2km. Figure 4 below shows the general layout of a simulation.¹⁸ Results include instances where the victim receiver was at or above its stated sensitivity.

¹⁷ Out-of-band emissions are based on the sub 1 GHz 3GPP 10 MHz base station emission mask. NextNav has argued that the actual emissions are lower than the mask, but, as NextNav is seeking to deploy a 5G system, the upper limit of what is allowed by 3GPP in terms of out-of-band emissions is the appropriate point for analysis. While out-of-band emissions were factored in, each receiver also used a blocking mask to restrict the amount of out-of-band energy. The simulation examined the interference from a three-sector 5G site to a single unlicensed 900 MHz device. A total of 200,000 instances were run for each case.

¹⁸ Device and simulation parameters can be found in Appendix A.

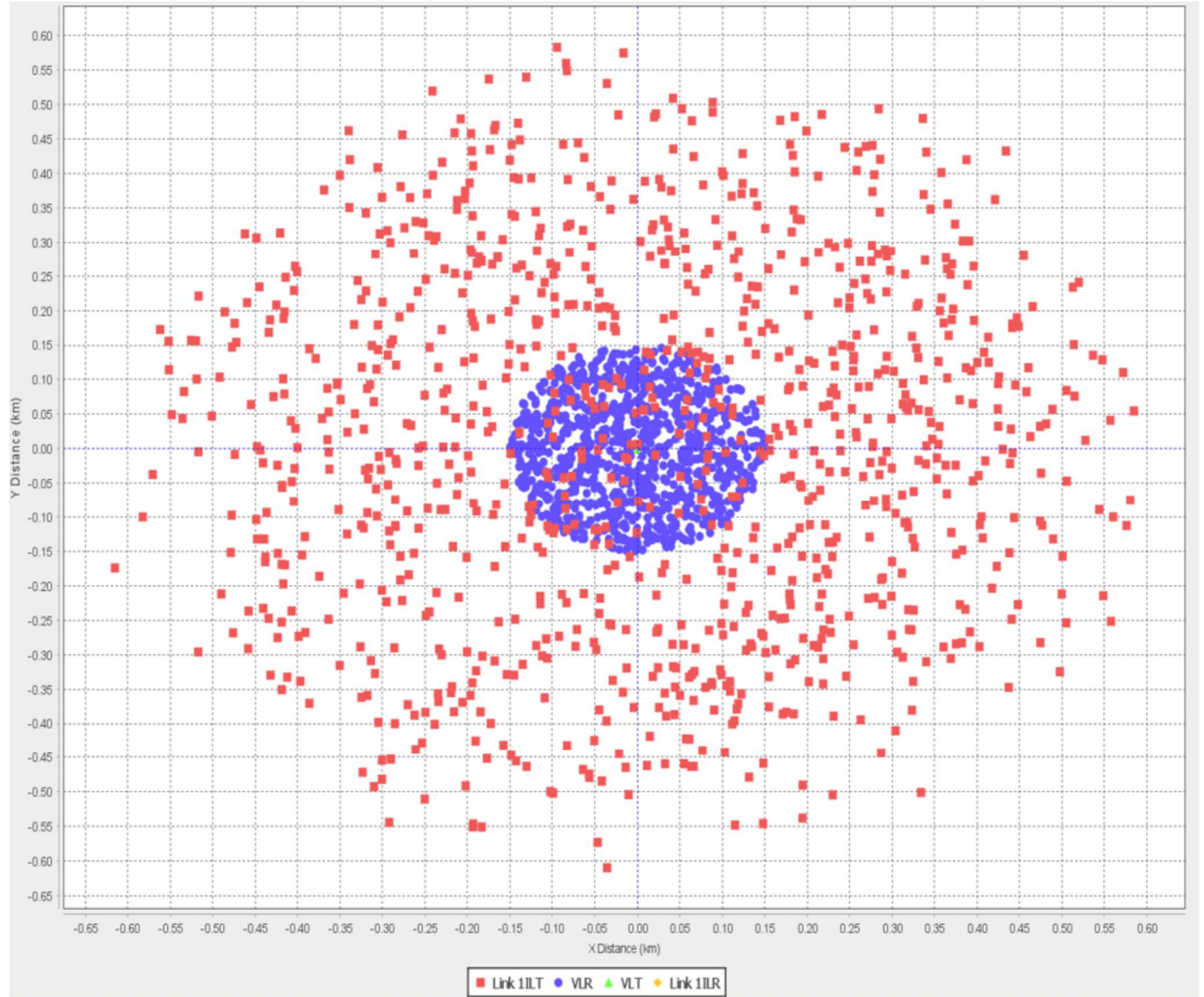


Figure 4 – 0.5km Simulation Layout

The simulation above plots the interfering 5G downlink transmitter (red), victim link receiver (blue), and the victim link transmitter (green) in the center. This simulation moves the victim receiver inside a defined coverage radius while values such as path loss and channel frequency are varied. The interfering link transmitter (5G base station) is moved throughout the 0.5 km radius while using a transmitter with an EIRP that is within a gaussian distribution using a center of +43 dBm and a standard deviation of 1. The transmitter signal is then fed into a 15 dBi gain antenna with a 65-degree bandwidth and downtilt of 4 degrees. These parameters are consistent with 5G base station power levels and antenna system design, and the simulation uses a conservative 50% loading factor. A breakdown of the statistical distribution of desired received power and interference power, both co-channel and blocking, can be seen below in Figure 5.

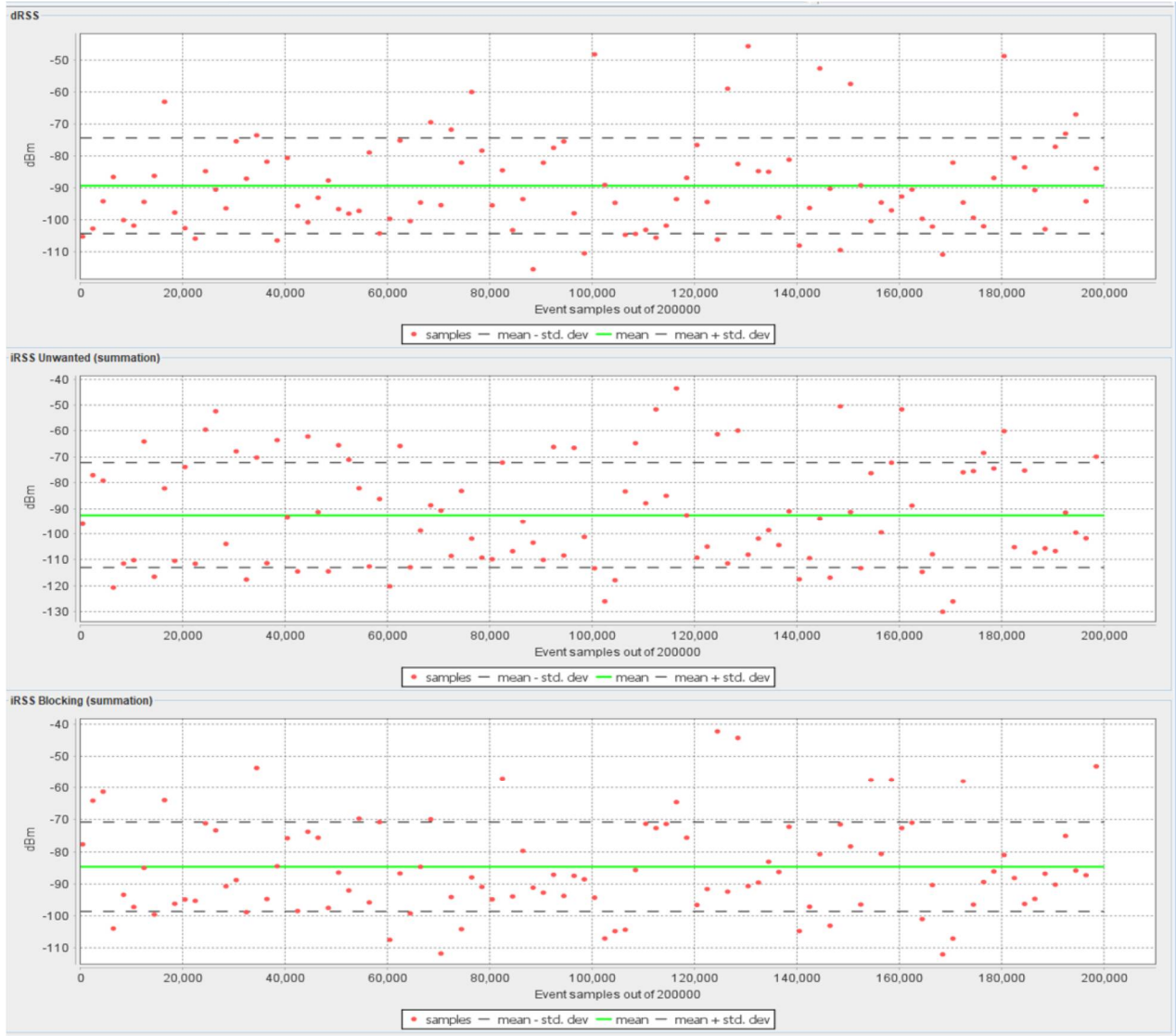


Figure 5 - Statistical Breakdown of 0.5 km Simulation

The figure above shows that the mean desired signal value is at roughly -89.3 dBm on a device with a sensitivity of -105 dBm, meaning that, while this device requires a minimum signal level of -105 dBm, in the simulation it received an average signal level of -89.3 dBm. Furthermore, the mean of the co-channel interference power (iRSS Unwanted) is at -92.6 dBm, and the total blocking power (iRSS Blocking), which accounts for blocking masks, is roughly -84.7 dBm. Blocking is the receiver's ability to deal with strong signals that are not necessarily on the same frequency that the receiver is using but, instead, are on a nearby frequency, such as the NextNav downlink. Not including blocking, these figures reflect a degradation in sensitivity of Part 15 narrowband devices of roughly 30 dB; in terms of milliwatts, the desired signal would need to be 1,000 times stronger for the device to function and overcome NextNav interference.

This interference is not only caused by NextNav emissions immediately within NextNav's proposed uplink and downlink channels, but also the out-of-band emissions of NextNav radios in

the remainder of the Lower 900 MHz Band. These emissions can be particularly significant when extremely strong base stations are near weaker radios, such as these unlicensed Part 15 devices. A total cumulative distribution function (CDF) for this specific case can be seen below.¹⁹

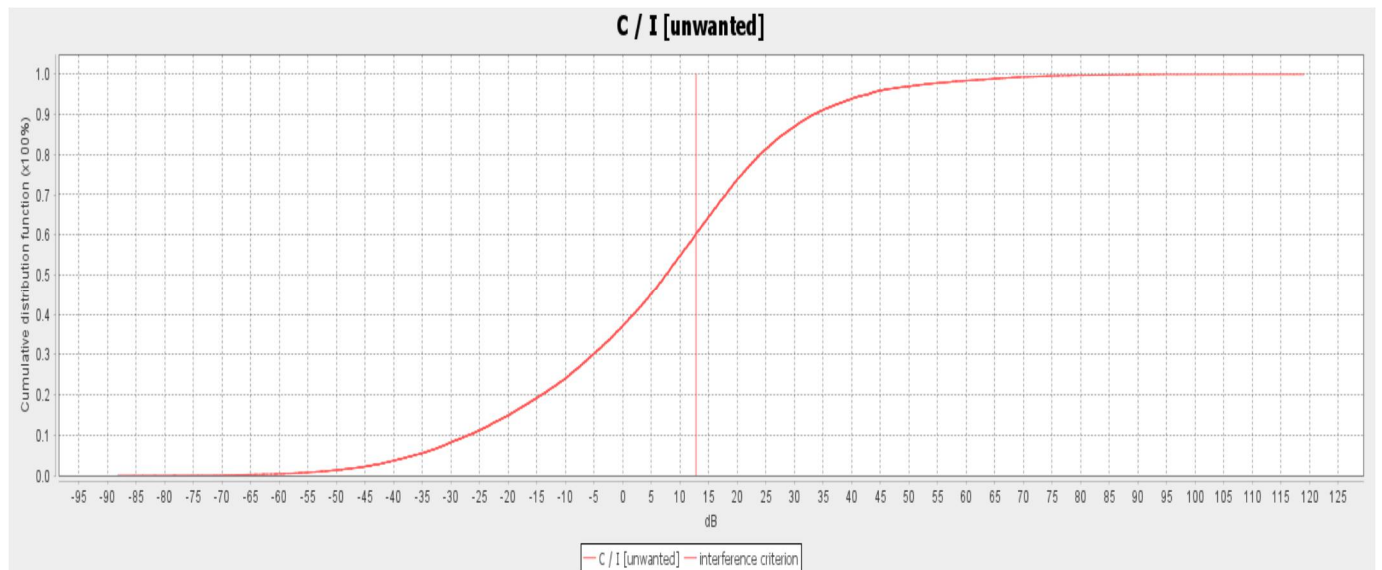


Figure 6 - 0.5km CDF

Figure 6 shows a CDF with an interference probability of 60% given the 200,000 independent instances of the simulation that were run. The CDF is a line plotted from the desired signal strength of the victim receiver for each of the simulations; any part of the line that is to the left of the “C/I” line represents an instance where the NextNav interference would be too strong to overcome. Tables 2 and 3 below show the probability of interference for three Lower 900 MHz Band devices: a “900 Narrowband,” a wireless microphone, and a wireless camera, with Table 2 showing just co-channel interference and Table 3 showing co-channel and blocking interference.

¹⁹ A distribution for all three scenarios is provided in Appendix C.

Table 2: Probability of Interference from Monte Carlo Simulations

NextNav Coverage Radius (km)	900 Narrowband	Wireless Mic	Wireless Camera (802.11ah 2 MHz channel)
2.0	22.6%	25.9%	29.4%
1.5	27.7%	29.9%	34.6%
1.0	37.0%	36.7%	41.2%
0.5	60.0%	52.4%	57.0%

Table 3: Probability of Interference and Blocking from Monte Carlo Simulations

NextNav Coverage Radius (km)	900 Narrowband	Wireless Mic	Wireless Camera (802.11ah 2 MHz channel)
2.0	41.8%	31.0%	60.3%
1.5	52.6%	37.5%	70.4%
1.0	66.7%	48.2%	82.0%
0.5	84.7%	67.4%	93.8%

As this data demonstrates, the interference and blocking from NextNav’s proposed network are dramatic. Even at a 2.0 km radius, an incumbent wireless camera will experience blocking more than 60% of the time, effectively rendering it useless.²⁰ Of course, the problem is even more consequential as the radius shrinks.

3.0 Overall Impact

The effects of the harmful interference caused by NextNav’s proposal would be felt in virtually every household in the country. According to the best estimates from current users of the band, there are billions of incumbent devices actively using the Lower 900 MHz Band,²¹ with more added every day. As noted, these devices span a wide range of uses, but we focus on one category in greater detail: residential security, alarm, and monitoring devices. It is reasonable to

²⁰ Devices using Z-Wave technologies would also be considered to be narrowband devices, while cameras and devices using microphones require larger bandwidths.

²¹ See, e.g., Reply Comments of Itron, Inc. at 4, WT Docket No. 24-240 (Sept. 20, 2024) (stating that there are “[b]illions of unlicensed devices in the 902-928 MHz band”); Reply Comments of the Connected Devices for America Coalition at 8, WT Docket No. 24-240, WT Docket No. 25-110 (May 13, 2025) (stating that there are “billions of already installed devices” in the Lower 900 MHz Band).

assume that, at a minimum, one-tenth of the Lower 900 MHz Band devices in use are residential security, alarm, or monitoring systems - meaning that, with an estimate of five billion devices in total, there are approximately 500 million such incumbent devices using the band. This equates to an average of 3.9 devices per household (based on a 2020 U.S. Census total of 126.8 million households nationwide).²²

An urban area is considered an area with at least 200 housing units (*i.e.*, occupied housing units) per square mile.²³ A coverage radius of two miles and 3.8 devices per household means that there will be more than 2,500 affected devices within the coverage radius of each NextNav site.

As a general rule, wireless security devices have a heartbeat/check-in time of approximately one hour, meaning each device “checks in” with its hub once per hour. With more than 2,500 devices within the radius for each site, approximately 42 devices will “check in” with their hub every minute – meaning that, at least 42 times every minute, there is the possibility of interference to both the uplink and downlink of a 5G network. This amount of interference would simply be unacceptable, because the user experience would be intolerable.

4.0 Conclusion

The modeling and simulations described in this report show clearly that, not only is coexistence between incumbent Part 15 devices and NextNav’s proposed system not possible, the deployment of a 5G network as proposed by NextNav would make the entire Lower 900 MHz Band unusable by both incumbent unlicensed devices and NextNav users alike. As a result, an enormous number of public safety and mission-critical devices would be rendered inoperable, leaving smoke detectors, flood sensors, panic buttons, and countless other devices unmonitored and unable to report emergencies. The wildly disparate network topologies between a low-power, short-range, narrowband device and a high-power, wide-area, OFDM network are simply not compatible in the same or adjacent spectrum.

²² U.S. Census Bureau, *Households and Families: 2020*,
<https://www.census.gov/library/publications/2024/dec/c2020br-10.html>.

²³ U.S. Census Bureau, *Redefining Urban Areas Following the 2020 Census*,
<https://www.census.gov/newsroom/blogs/random-samplings/2022/12/redefining-urban-areas-following-2020-census.html>.

Appendix A

General Wide Area Modeling Parameters	
Propagation Model	Anderson 2d
Clutter	USGS 2024
Clutter Values	TSB-88
Elevation Data	USGS 2024
5G Parameters	
Frequency	923 MHz
Transmit Antenna Height	Approximate building height
Transmit Antenna Type	65 degree (Andrew 2P-2L-C1-V2)
Sector Azimuths	0,120,240 degrees
EIRP	+66 dBm
Receive Antenna Type	Omni 2.1 dBi gain
Receive Antenna Height	1.5m

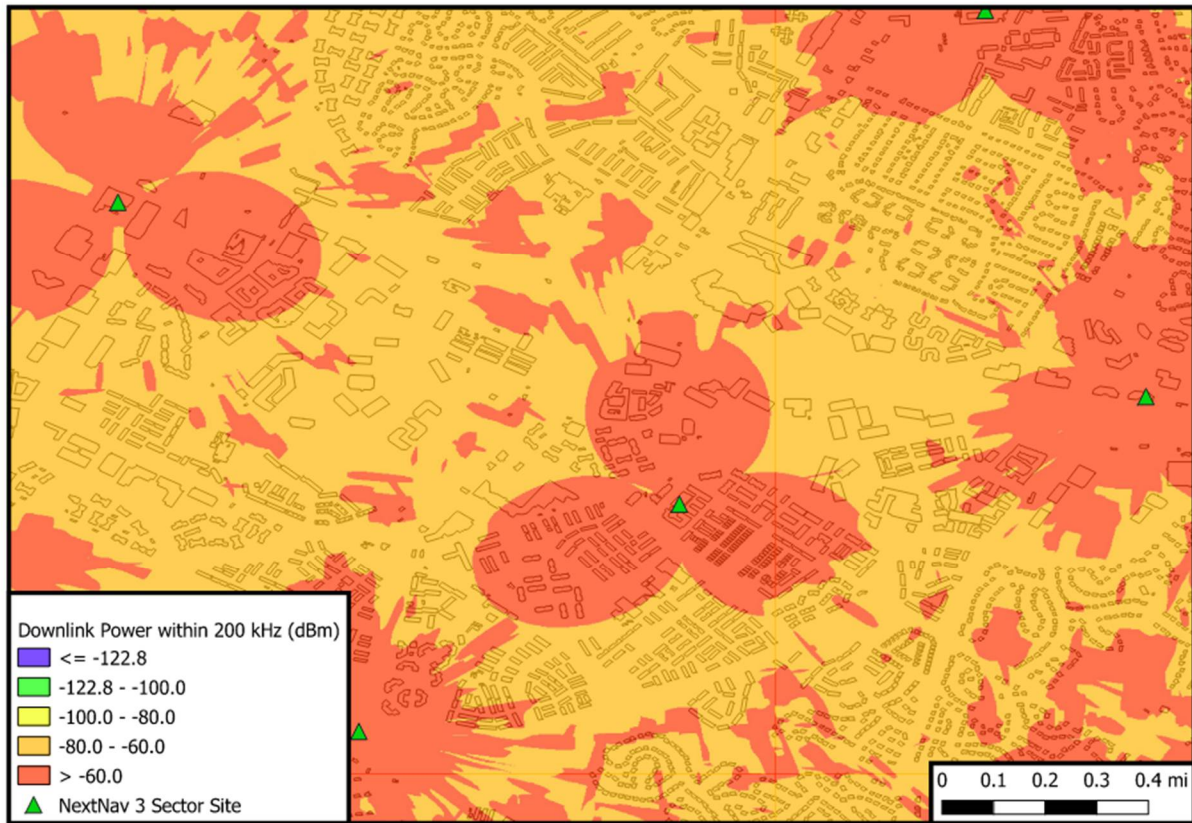
Monte Carlo Simulation Parameters		
Narrowband Victim Transceiver		
	Frequency	912.75 – 919.25 MHz
	Number of Channels	50
	Channel Bandwidth	130 kHz
	Block and Selectivity	40 dB at 200 kHz
	Transmit Power	+20 dBm
	Sensitivity	-105 dBm
	Transmit Antenna Type	Omni 2.1 dBi gain
	Transmit Antenna Height	1.5m
	Receive Antenna Type	Omni 2.1 dBi gain
	Receive Antenna Height	1.5m
	Propagation Model	3GPP TR38.901 (Indoor NLoS)
	Coverage Radius	150m
	Transmit Antenna Environment	100% Indoor
	Receive Antenna Environment	25% Outdoor 75% Indoor

Wireless Microphone Victim Transceiver		
	Frequency	902.5 – 927.5 MHz
	Number of Channels	51
	Channel Bandwidth	500 kHz
	Block and Selectivity	40 dB at 500 kHz
	Transmit Power	+21 dBm
	Sensitivity	-94 dBm
	Transmit Antenna Type	Omni 2.1 dBi gain
	Transmit Antenna Height	1.5m
	Receive Antenna Type	Omni 2.1 dBi gain
	Receive Antenna Height	1.5m
	Propagation Model	3 GPP TR38.901 (Indoor NLoS)
	Coverage Radius	60m
	Transmit Antenna Environment	100% Indoor
	Receive Antenna Environment	50% Outdoor 50% Indoor
802.11ah Victim Transceiver		
	Frequency	906 – 926 MHz
	Number of Channels	4
	Channel Bandwidth	2 MHz
	Block and Selectivity	12 dB at 2 MHz
	Transmit Power	+13 dBm
	Sensitivity	-93 dBm
	Transmit Antenna Type	Omni 2.1 dBi gain
	Transmit Antenna Height	1.5m
	Receive Antenna Type	Omni 2.1 dBi gain
	Receive Antenna Height	1.5m
	Propagation Model	3 GPP TR38.901 (Indoor NLoS)
	Coverage Radius	50m

	Transmit Antenna Environment	100% Outdoor
	Receive Antenna Environment	100% Indoor
Interfering 5G Transmitter		
	Frequency	923 MHz
	Channel Bandwidth	10 MHz (3 GPP Sub 1 GHz Emission Mask)
	Transmit Azimuth	3 Sector Site (0,120,240)
	Transmit Power	Gaussian Distribution +43 dBm with 1dB Std Dev.
	Transmit Antenna Type	ITU-R f.1336-4 rec 3 (65 degree, 15 dBi gain, 4-degree downtilt)
	Transmit Antenna Height	30m
	Propagation Model	3 GPP TR38.901 (urban)
	Coverage Radius	Varies (0.5,1,1.5,2 km)
	Transmit Antenna Environment	100% Outdoor
	System Layout	Single Site Hexagonal

Appendix B

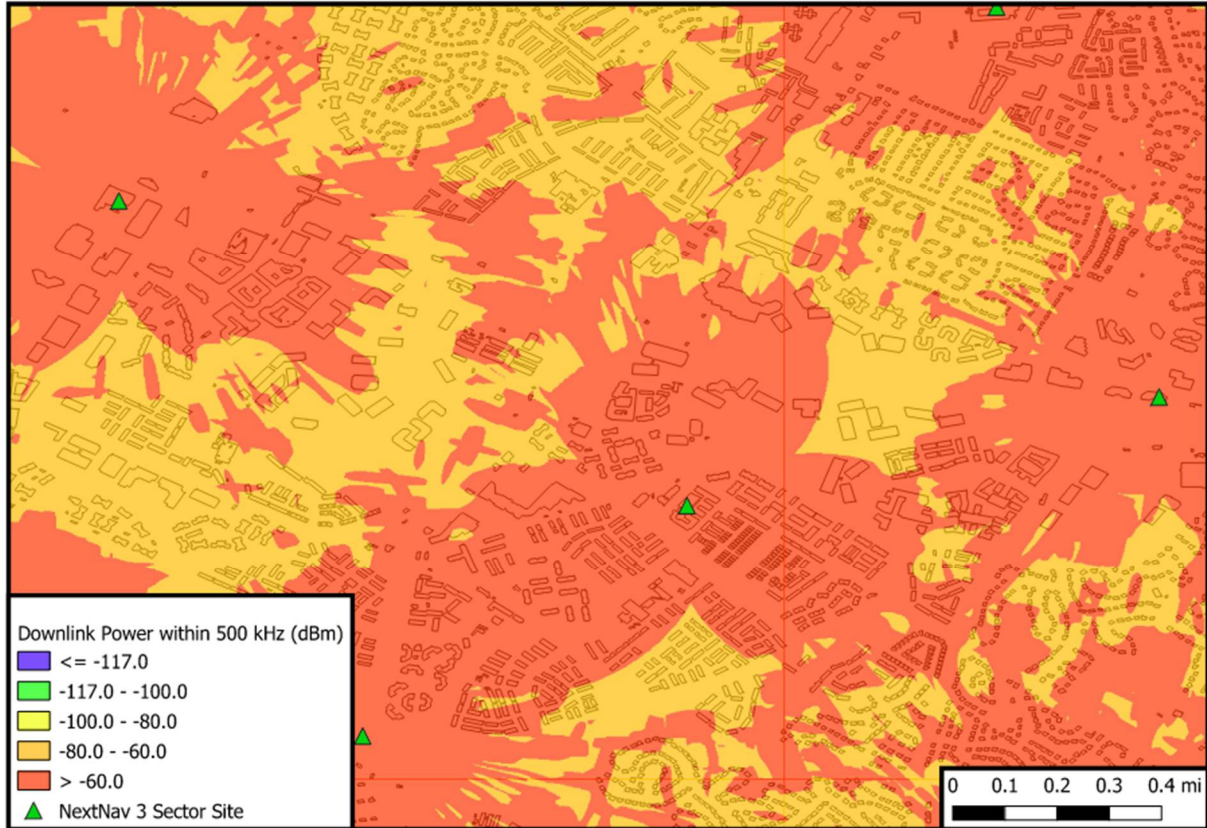
NextNav Downlink Power within 200 kHz Bandwidth



7/28/25

Pericle Communications Company

NextNav Downlink Power within 500 kHz Bandwidth



7/28/25

Pericle Communications Company

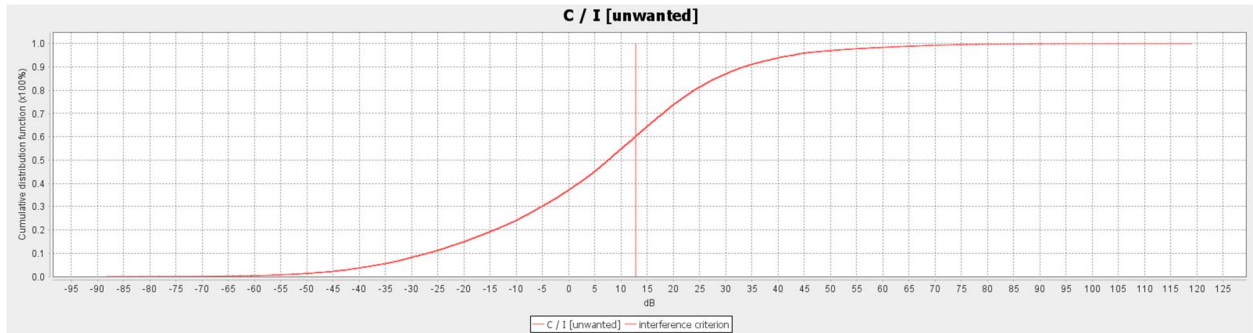
NextNav Downlink Power within 2 MHz 802.11ah Bandwidth



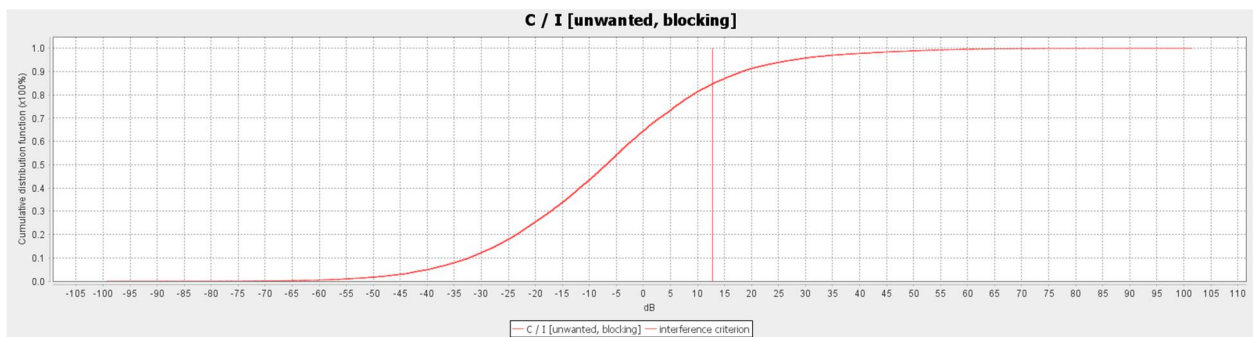
7/28/25

Pericle Communications Company

Appendix C



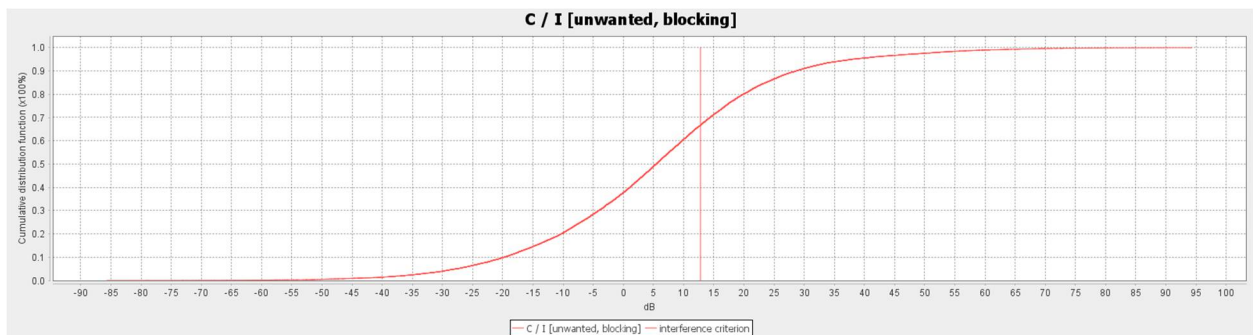
0.5 km Narrowband Interference CDF



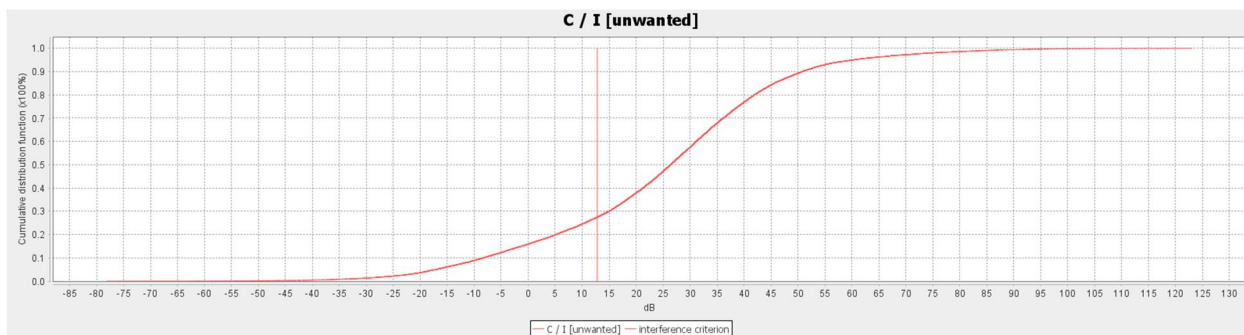
0.5 km Narrowband Interference and Blocking CDF



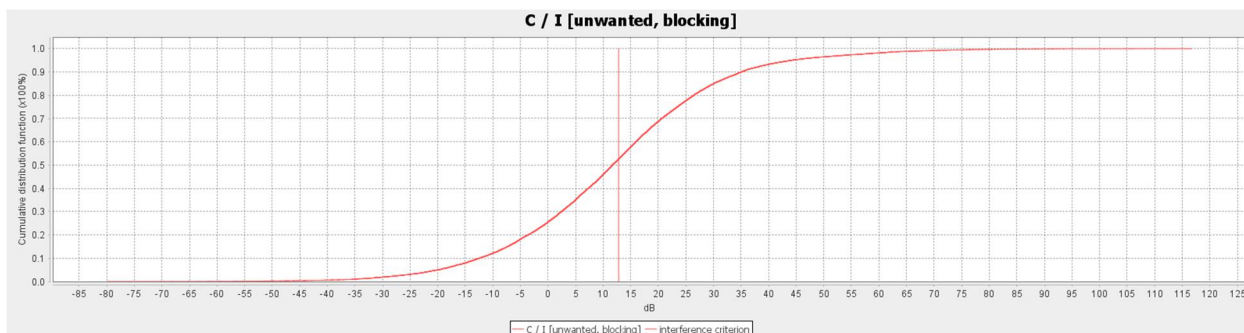
1 km Narrowband Interference CDF



1 km Narrowband Interference and Blocking CDF



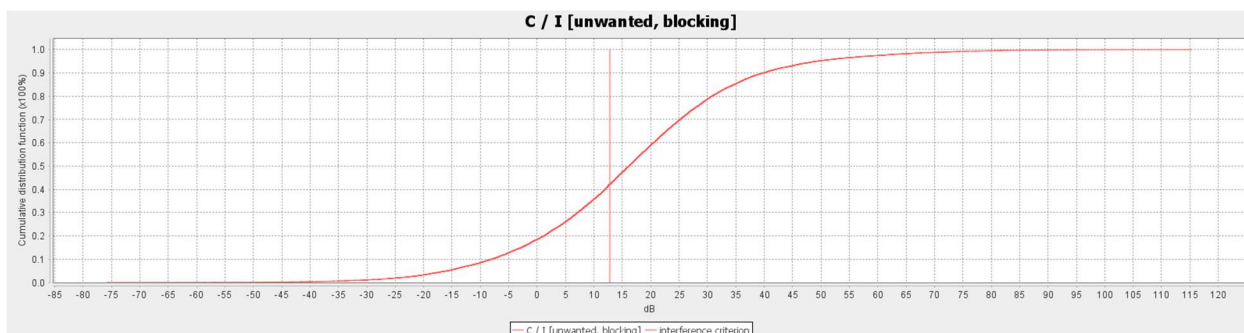
1.5 km Narrowband Interference CDF



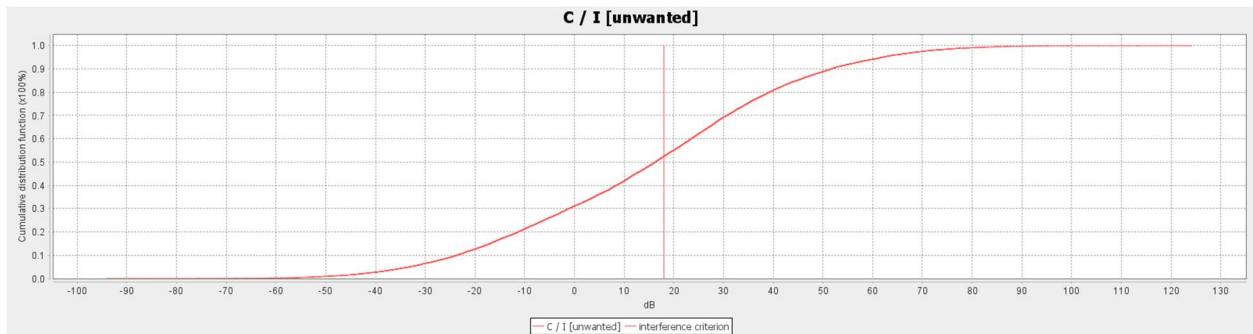
1.5 km Narrowband Interference and Blocking CDF



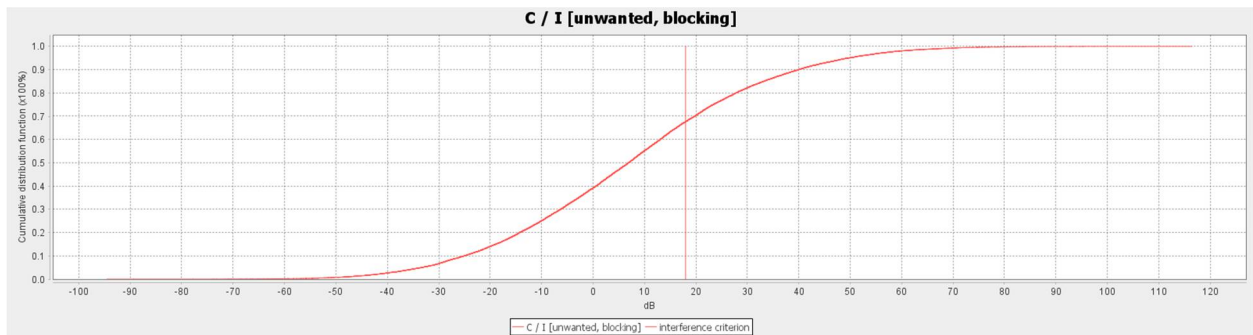
2 km Narrowband Interference CDF



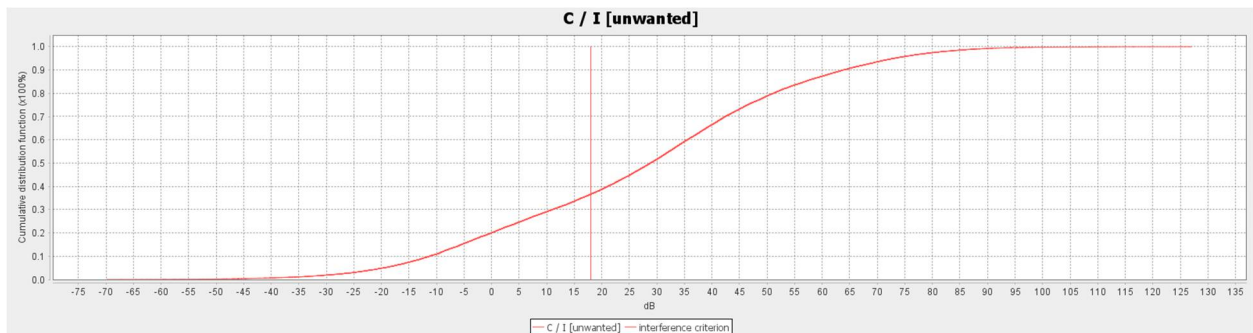
2 km Narrowband Interference and Blocking CDF



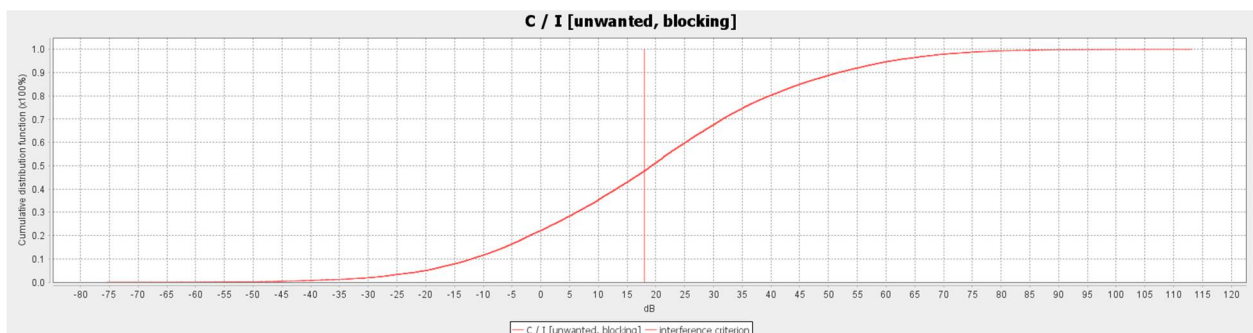
0.5 km Wireless Microphone Interference CDF



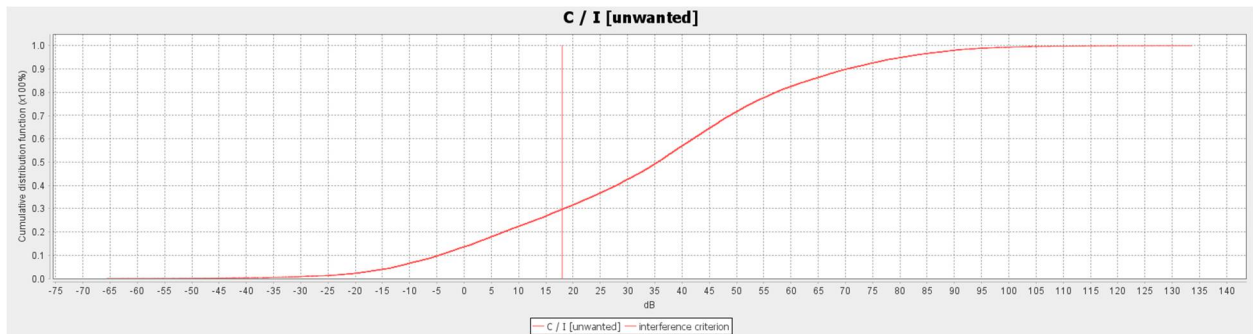
0.5 km Wireless Microphone Interference and Blocking CDF



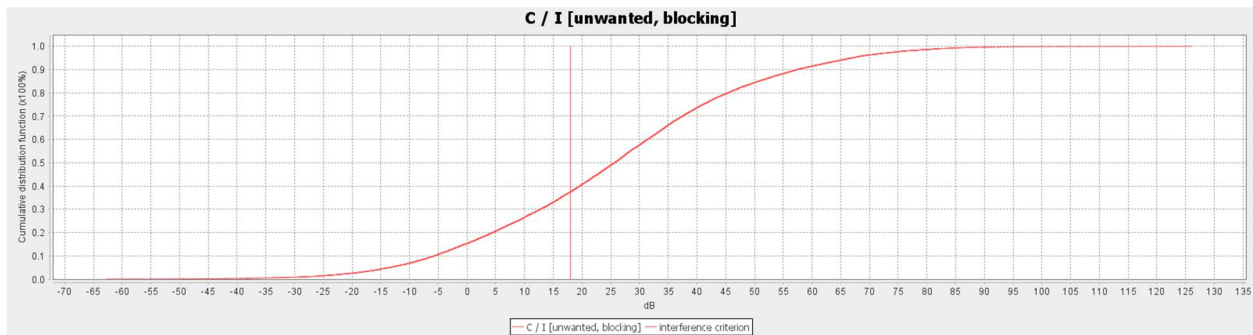
1 km Wireless Microphone Interference CDF



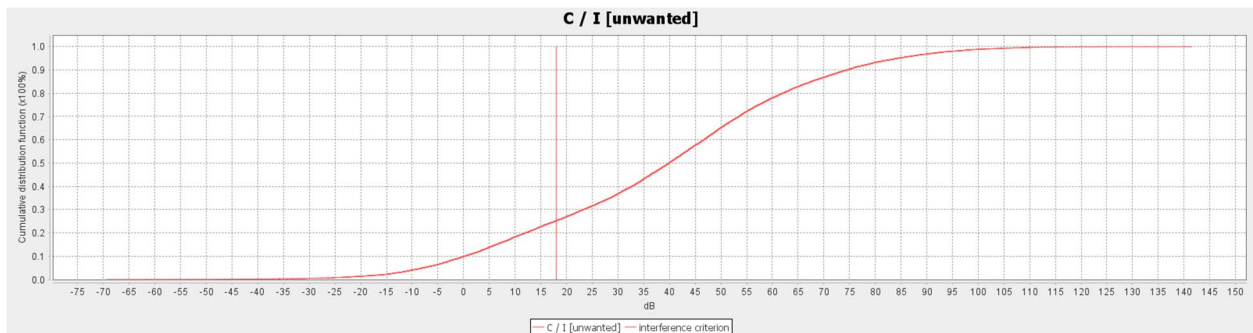
1 km Wireless Microphone Interference and Blocking CDF



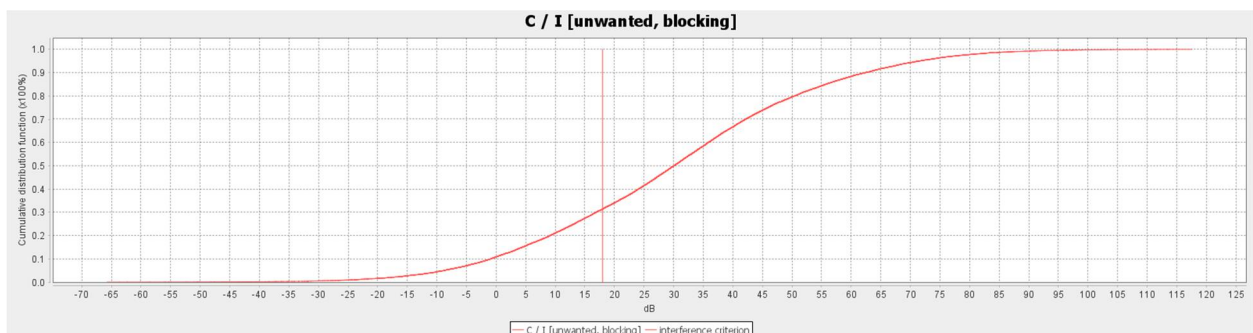
1.5 km Wireless Microphone Interference CDF



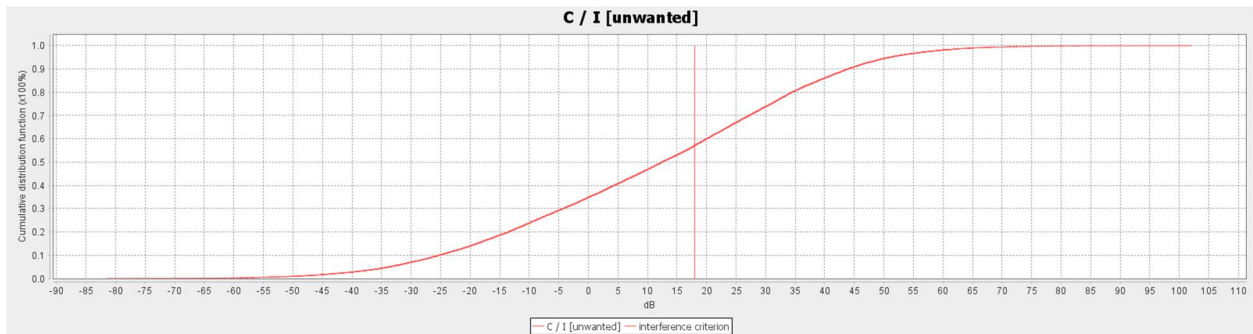
1.5 km Wireless Microphone Interference and Blocking CDF



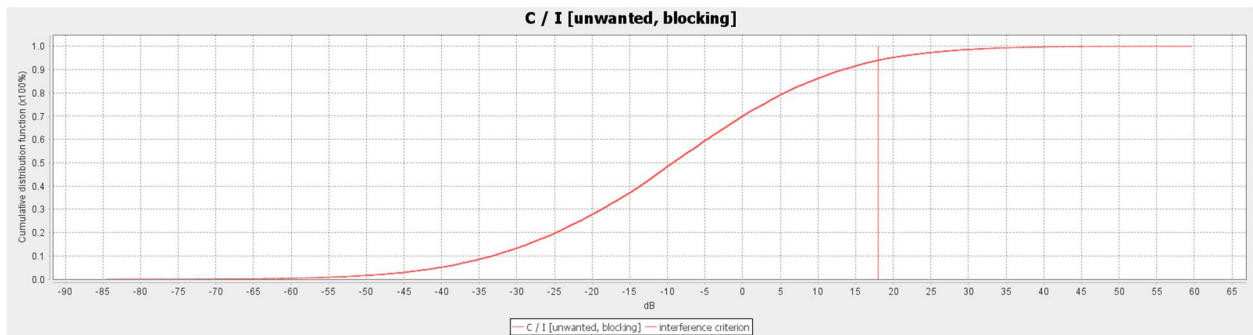
2 km Wireless Microphone Interference CDF



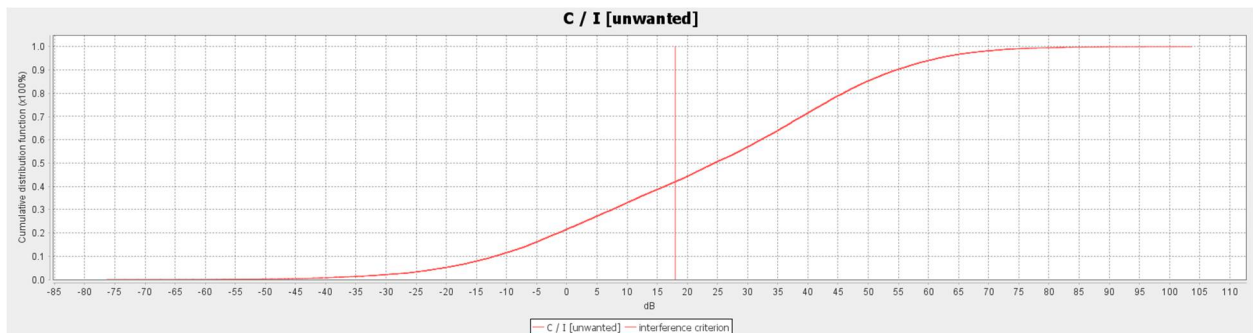
2 km Wireless Microphone Interference and Blocking CDF



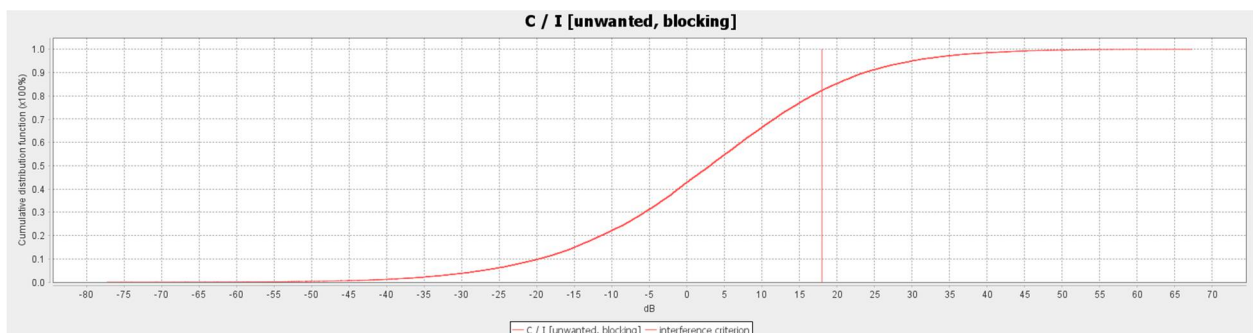
0.5 km 802.11ah 2 MHz Interference CDF



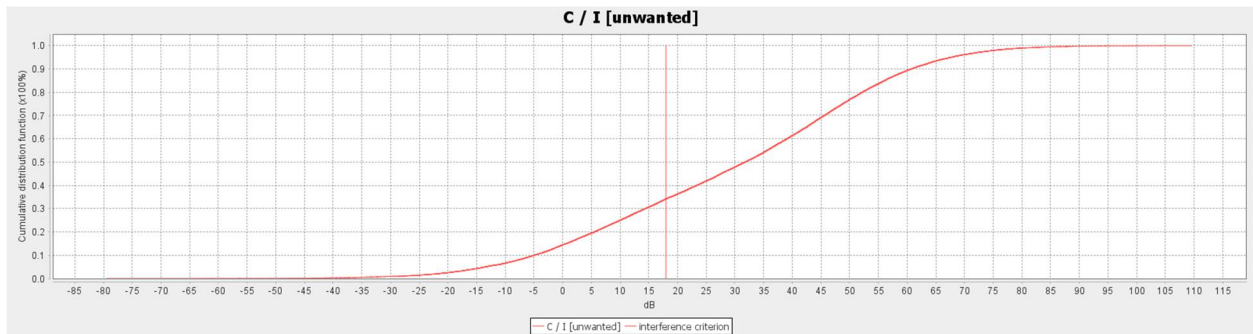
0.5 km 802.11ah 2 MHz Interference and Blocking CDF



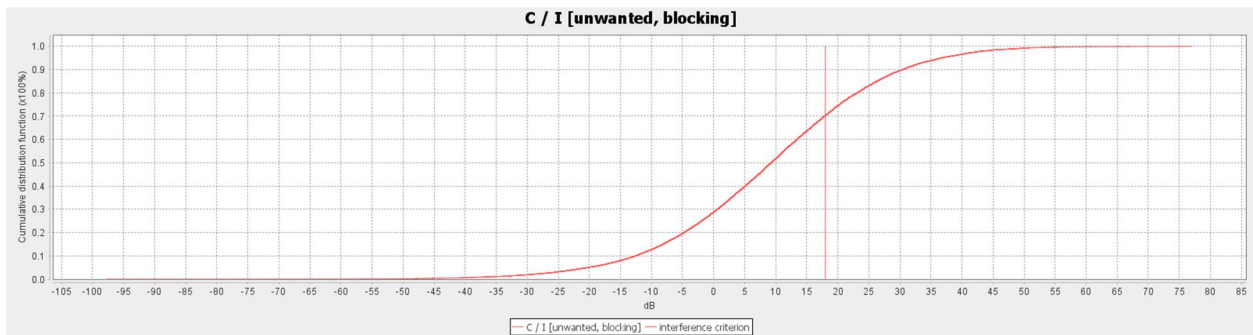
1 km 802.11ah 2 MHz Interference CDF



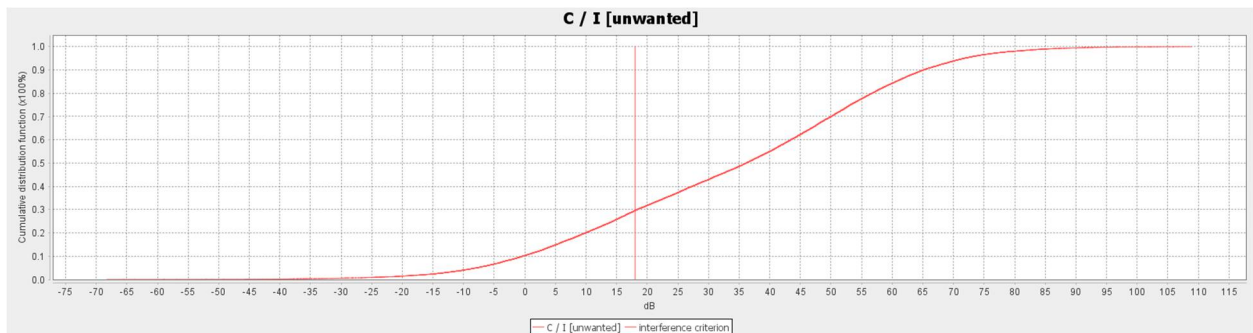
1 km 802.11ah 2 MHz Interference and Blocking CDF



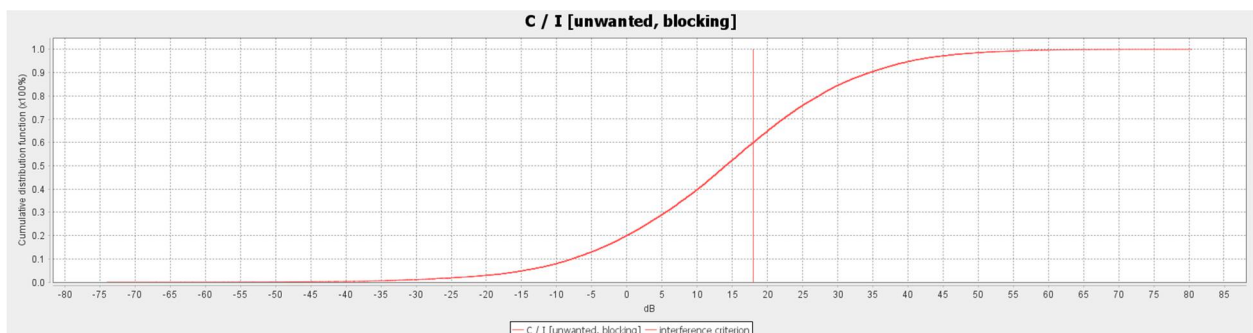
1.5 km 802.11ah 2 MHz Interference



1.5 km 802.11ah 2 MHz Interference and Blocking CDF



2 km 802.11ah 2 MHz Interference CDF



2 km 802.11ah 2 MHz Interference and Blocking CDF

June 4, 2026

Dear Chairman Guthrie, Ranking Member Pallone, Subcommittee Chairman Hudson, and Subcommittee Ranking Member Matsui:

The Electronic Security Association (ESA) represents thousands of electronic security and life safety companies across the United States that design, install, monitor, and maintain systems protecting homes, businesses, schools, healthcare facilities, critical infrastructure, and public institutions.

We are deeply concerned by proposals that would fundamentally alter the 902-928 MHz spectrum band. For decades, the Lower 900 MHz band has served as a critical spectrum resource supporting a broad ecosystem of low-power devices relied upon throughout the electronic security and life safety industry. Alarm systems, panic and duress devices, personal emergency response systems (PERS), access control systems, and many other mission-critical life safety applications depend upon reliable access to this spectrum.

Unlike many consumer technologies, electronic security and life safety systems are specifically designed to function during emergencies when reliability is paramount. These devices are expected to transmit alarm signals, communicate emergency events, support first responders, and provide situational awareness during fires, medical emergencies, criminal incidents, natural disasters, and other critical events. Any degradation in reliability or increase in interference risk could have consequences that extend well beyond economic impacts and directly affect public safety.

NextNav's proposal to restructure the Lower 900 MHz band would introduce high-power terrestrial operations into a spectrum environment that has successfully supported low-power incumbent users for decades. This fundamental change raises serious concerns regarding harmful interference, degraded system performance, reduced reliability, and increased operational costs for both providers and end users.

The security and life safety industry has invested billions of dollars in equipment, infrastructure, and deployed systems designed around the FCC's longstanding framework governing the Lower 900 MHz band. Additionally, replacing, retrofitting, or redesigning these systems would impose substantial costs on businesses, consumers, schools, healthcare facilities, and government entities while potentially creating gaps in life safety coverage during transition periods.

As Congress continues its important work on PNT resiliency and spectrum policy, we respectfully urge policymakers to protect incumbent users of the Lower 900 MHz band and reject proposals that would create harmful interference risks for critical life safety technologies.

Thank you for your consideration of these concerns and for your continued leadership on communications, technology, and public safety issues.

Respectfully submitted,

Taylor Criddle
Vice President of Advocacy and Public Affairs
Electronic Security Association

STATEMENT FOR THE RECORD

Submitted to the

United States House of Representatives

Committee on Energy and Commerce

Hearing on Positioning, Navigation, and Timing (PNT): Technologies and Security

June 4, 2026

Submitted by:

Digital Global Systems

Introduction

Digital Global Systems (DGS) respectfully submits this statement for the record in connection with the Committee's hearing on Positioning, Navigation, and Timing (PNT) security. DGS is an RF (radio frequency) awareness and spectrum intelligence company with more than 725 issued and pending patents, including patent priority dates extending back to 2013. Our work spans military, government, and commercial markets across four continents, and our core competency, RF Awareness, is directly relevant to the security vulnerabilities this hearing addresses.

PNT Security Is, Fundamentally, an RF Problem

The United States' dependence on GPS-based PNT infrastructure is well documented. Financial settlement systems, power grid synchronization, air traffic control, precision agriculture, and emergency response all rely on GPS timing signals operating in a narrow band around 1.2-1.6 GHz. That dependence is also a vulnerability: GPS signals arrive at the Earth's surface at extremely low power levels, making them susceptible to high-power jamming (signal denial) and spoofing (false signal injection) using commercially available equipment.

The threat is not theoretical. GPS jamming and spoofing incidents have been documented near conflict zones, major commercial ports, and domestic critical infrastructure. In each case, the attack originates in the RF domain, yet most systems that depend on PNT have no visibility into it. They consume the GPS signal without monitoring the RF environment that delivers it.

This is the core vulnerability: you cannot defend against an RF attack you cannot detect.

RF Visibility Is the Prerequisite for PNT Resilience

Resilient PNT architectures, whether based on alternative positioning systems, multi-constellation receivers, or inertial navigation backups, share a common dependency: operators must know when the primary GPS signal has been compromised before they can invoke a backup. Without real-time RF-domain awareness, there is no reliable mechanism to detect a spoofing event in progress, distinguish a jamming attack from natural interference, or determine when it is safe to return to reliance on GPS.

DGS provides continuous, passive monitoring of the RF spectrum across the frequencies relevant to GPS and alternative PNT signals, from 40 MHz to 6 GHz. Our CLEARSKY™ platform detects and classifies anomalous RF activity, including unauthorized emissions, jamming signatures, and signals inconsistent with the expected RF environment, without requiring a pre-built signature library. Classification occurs in under two seconds. This capability provides

operators with early warnings to take protective action and security and intelligence teams with the forensic data required to characterize and attribute the threat.

RF Awareness does not replace GPS or alternative PNT systems. It makes them trustworthy by providing operators with the environmental context needed to determine whether the signals those systems receive are valid.

Recommendations for the Committee

DGS respectfully offers the following recommendations as the Committee considers legislative and policy responses to PNT security risks.

1. **Require RF domain monitoring as a component of any resilient PNT framework.** Federal standards for resilient PNT, whether issued by NIST, DHS, or DOD, should require continuous monitoring of the RF environment at sites where GPS-dependent critical infrastructure is deployed. Backup positioning systems have limited value if an operator cannot detect that the primary or secondary system has been compromised, how the primary system was compromised, and whether partial data from the primary system can be used in conjunction with the secondary system.
2. **Fund RF threat detection capabilities within the National Spectrum Strategy.** The Administration's National Spectrum Strategy identifies spectrum security as a priority, but does not yet provide specific direction on RF-domain threat detection. Congress should direct NTIA, in coordination with DHS CISA, to establish minimum RF monitoring requirements for federally regulated critical infrastructure sectors.
3. **Invest in domestic RF Awareness technology.** The United States should not rely on foreign-sourced spectrum-monitoring equipment to protect its most critical timing infrastructure. DGS is a U.S.-based company with a substantial domestic patent portfolio in RF awareness, anomalous signal detection, and AI-based spectrum analysis. Federal procurement and R&D investment programs should prioritize companies with proven domestic IP and deployment experience.

Conclusion

PNT security cannot be achieved by adding backup systems alone. It requires persistent visibility into the RF environment in which those systems operate. DGS has spent more than a decade developing exactly that capability, and we welcome the opportunity to contribute our technical expertise to the Committee's work on this critical issue.

Contact:

Digital Global Systems
Armando Montalvo, CTO
amontalvo@digitalglobalsystems.com
www.digitalglobalsystems.com

June 3, 2026

The Honorable Brendan Carr
Chairman
Federal Communications Commission
45 L Street NE
Washington, DC 20554

RE: Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions (WT Docket No. 25-110); Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking (WT Docket No. 24-240)

Dear Chairman Carr:

The undersigned organizations write to express our strong support for the Federal Communications Commission’s (“FCC”) efforts to create a resilient backup to the Global Positioning System (“GPS”) through complementary Position, Navigation, and Timing (“PNT”) solutions. GPS is essential to the American economy, national security, public safety, transportation, energy infrastructure, and everyday life. We support continued federal work to identify and test technologies that can strengthen GPS resilience.

At the same time, we write to express deep opposition to any effort to reconfigure the 902-928 MHz radiofrequency spectrum range (“Lower 900 MHz Band”) as part of that process. Specifically, NextNav, Inc. (“NextNav”) has petitioned¹ the FCC to reconfigure the Lower 900 MHz Band. The record evidence is overwhelming: NextNav’s proposal would impose hundreds of billions of dollars in certain, largely irreversible economic harm on American consumers, businesses, utilities, and government agencies in exchange for speculative PNT benefits achievable through far less harmful means.

If granted, the NextNav proposal would fundamentally upend a band that has supported a productive, shared wireless ecosystem for decades. For 30 years, the FCC’s rules for the Lower 900 MHz Band have allowed for the proliferation of licensed and unlicensed users in this band, backed by billions of dollars of investment in building out these devices and services to specifically operate on these frequencies. As outlined by the breadth and depth of stakeholder filings in opposition to NextNav’s petition within the FCC docket, the band now supports an active and diverse ecosystem. First responder equipment, flood and dam control systems, medical alert devices, public utility infrastructure, railroad safety systems, home security devices, baby monitors, supply chain logistics for retailers and grocers, transportation and tolling systems, commercial and civil aviation, amateur radios, and the Internet of Things (IoT) ecosystem rely on this band to enable critical services that consumers and business rely on.

¹ NextNav Petition for Rulemaking, Enabling Next-Generation Terrestrial Positioning, Navigation, and Timing and 5G: A Plan for the Lower 900 MHz Band (902-928 MHz), Public Notice, WT Docket No. 24-240 (rel. Aug. 6, 2024) (“Public Notice”). <https://www.fcc.gov/ecfs/search/docket-detail/24-240>.

The practical effect of this petition is straightforward: NextNav’s proposal would introduce high-power 5G operations into a band built around low-power coexistence, significantly reduce the amount of spectrum available for lower power operations, fundamentally change the operating environment for many unlicensed devices (potentially rendering them unusable), and alter the rules that have protected hundreds of millions of deployed devices for decades. That combination creates serious risks of interference, degraded performance, stranded investment, and higher costs across the economy.

Independent analysis establishes that the costs of NextNav's proposal vastly exceed any claimed benefit. In the utility sector alone, replacing deployed smart meters would create approximately \$100 billion in estimated direct costs for electricity utility infrastructure and could add another 50% to total gas and water utility ratepayer cost increases.² The cost of replacing RFID systems relied on for inventory and logistics is estimated to be at least \$5.0–\$7.2 billion.³ The Furchtgott-Roth study concluded that the benefits of NextNav's proposal amount to no more than \$1.2–\$2.1 billion in value, while the costs run into the tens of billions.⁴ For context, NextNav's own economic analysis values its entire PNT solution at just \$14.6 billion, a figure already dwarfed many times over by the combined costs imposed on utilities, retailers, toll operators, and other users alone.⁵ Notably, the Brattle Group, who conducted the economic analysis that NextNav cites, states the “total quantified value of having a terrestrial backup to GPS” is \$14.6 billion, which is not exclusive to NextNav’s technology and could be derived from other terrestrial GPS backup systems.⁶

Alongside the expected disruption and interference for incumbent users and impact to American consumers, NextNav’s proposed solution itself has inherent flaws. The plan NextNav advances for a GPS backup highlights the national security concerns inherent in potential disruption in international contested environments; however, its solution focuses on deployment within the continental United States, where GPS is readily available and where adversarial disruption is less immediate. NextNav’s proposal also falls technologically short of even providing a blanket national GPS backup. NextNav acknowledges that coverage would be “optimized where population and critical infrastructure are concentrated” but, in the future, they “can scale to rural areas as commercial 5G networks expand.”⁷ In the meantime, this would mean large gaps in coverage in the air and on the surface in rural, mountainous, and maritime corridors where 5G infrastructure has yet to expand, precisely the environment where a GPS backup would be most relevant from a national security perspective.⁸

² Itron, Inc., Generac Power Systems, Inc. and Landis+Gyr Ex Parte, FCC, WT Docket Nos. 24-240, 25-110 (Mar. 9, 2026).

³ RAIN Alliance Ex Parte, FCC, WT Docket Nos. 24-240, 25-110 (Mar. 9, 2026).

⁴ Harold Furchtgott-Roth, An Economic Analysis of NextNav's Proposal for the Reallocation of Spectrum, Furchtgott-Roth Economic Enterprises, FCC, WT Docket Nos. 24-240, 25-110, filed Apr. 28, 2025.

⁵ NextNav Ex Parte, FCC, WT Docket Nos. 25-110, 24-240, filed Jul. 17, 2025.

⁶ NextNav Inc., “NextNav Inc. Reports Third Quarter 2024 Results,” Exhibit 99.1 to Form 8-K, filed with the Securities and Exchange Commission, November 13, 2024, https://www.sec.gov/Archives/edgar/data/1865631/000121390024097469/ex991_1.htm.

⁷ NextNav LLC, *Building the Future of Geolocation: 5G-Powered 3D PNT*, <https://nextnav.com/building-the-future-of-geolocation-5g-powered-3d-pnt-dr-arun-raghupathy/> (last visited May 26, 2026).

⁸ Resilient Navigation & Timing Foundation, *The FCC Must Strengthen GPS Resilience* (Mar. 21, 2025), <https://rntfnd.org/2025/03/21/the-fcc-must-strengthen-gps-resilience-oped-washington-examiner/>.

Furthermore, NextNav itself has acknowledged that its proposed PNT system would require only 5 percent of the 15 MHz band it seeks.⁹ The company's own communications to shareholders confirm its vision for the remaining 95 percent of the spectrum: leasing to mobile network operators under flexible-use rules.¹⁰ In practice, this would ultimately mean converting a public resource that has been carefully balanced and shared for three decades into a high-power, licensed block built exclusively for a single company's business purpose.

NextNav's core premise that the Lower 900 MHz Band is lightly used and easily repurposed is demonstrably false. The band is foundational infrastructure for the American economy. More than 160 million electric, gas, and water smart meters rely on it as part of Advanced Metering Infrastructure (AMI) networks.¹¹ More than 120 million toll transponders are used in 33 states to process nearly 10 billion transactions annually, accounting for over \$25 billion in revenue that is invested for road maintenance.¹² The band hosts the globally standardized RFID standard used by retailers, logistics operators, and the Department of War (DoW) to track assets with more than 52.8 billion RFID-tagged products entering the U.S. supply chain in 2024 alone.¹³ Alarm systems, emergency monitoring devices, water and gas infrastructure, and hundreds of millions of consumer IoT devices also depend on this spectrum. The Lower 900 MHz Band ecosystem also supports industrial, telemetry, control, monitoring, logistics, IoT, and uncrewed systems applications. For three decades, industry has invested billions of dollars in direct reliance on the FCC's long-standing rules for this band.¹⁴

Additionally, many other viable alternatives exist that do not require reconfiguring the Lower 900 MHz Band. Other nations¹⁵ have deployed eLORAN networks, with signal strength three to five million times greater than GPS.¹⁶ The FCC has also identified low-Earth orbit (LEO) satellites as another promising option, given their proximity enables stronger signals than

⁹ See Petition for Rulemaking of NextNav Inc., WT Docket No. 24-240 at 27 (filed Apr. 16, 2024) (as supplemented by Letter from Robert Lantz, General Counsel, NextNav Inc., to Marlene H. Dortch, Secretary, FCC, WT Docket No. 24-240 (filed June 7, 2024)); see also Broadband Breakfast, FCC Flooded with Opposition to NextNav's GPS Backup Proposal, <https://broadbandbreakfast.com/fcc-flooded-with-opposition-to-nextnavs-gps-backup-proposal/> (last visited May 26, 2026).

¹⁰ NextNav LLC, *Lays Out New Vision*, <https://nextnav.com/lays-out-new-vision/> (last visited May 26, 2026).

¹¹ Itron, Inc., Generac Power Systems, Inc. and Landis+Gyr, Ex Parte, FCC, WT Docket Nos. 24-240, 25-110 (Mar. 9, 2026).

¹² International Bridge Tunnel & Turnpike Association (IBTTA), Ex Parte, FCC, WT Docket Nos. 24-240, 25-110 (Jul. 24, 2025).

¹³ RAIN Alliance Inc., Ex Parte, FCC, WT Docket Nos. 24-240, 25-110 (Mar. 9, 2026).

¹⁴ The RAIN Alliance, a consortium of over 200 member companies that use RAIN RFID technology, has estimated between \$5.0 and \$7.2 billion in direct costs just to RFID end users should the FCC adopt NextNav's proposal. See An Economic Analysis of the Harm Caused to RAIN RFID Devices from NextNav's Proposal for the Reallocation of Spectrum and the Modification of Rules in the Lower 900 MHz Band, Harold Furchtgott-Roth (Feb. 2026), attached to Letter from Aileen Ryan, RAIN Alliance, to Marlene H. Dortch, FCC, Secretary, WT Docket No. 25-110 (Mar. 9, 2026) ("RAIN Alliance Letter").

¹⁵ Resilient Navigation & Timing Foundation, *PNT GPS Critical Issue for New Administration and Congress* (Feb. 4, 2025), <https://rntfnd.org/2025/02/04/pnt-gps-critical-issue-for-new-administration-and-congress/>. Reuters, *South Korea Revives GPS Backup Project After Blaming North for Jamming*, <https://www.reuters.com/article/world/south-korea-revives-gps-backup-project-after-blaming-north-for-jamming-idUSKCN0XT01U/> (last visited May 26, 2026).

¹⁶ Hellen Systems, *Our Technology*, <https://hellensystems.com/our-technology/> (last visited May 26, 2026).

traditional GPS satellites.¹⁷ More broadly, the U.S. DOT Volpe Center is actively evaluating a wide range of complementary PNT technologies and has awarded more than \$12 million to at least fourteen vendors for real-world field testing.¹⁸ DOT completed Rapid Phase I testing¹⁹ in 2025 and Rapid Phase II testing remains underway through at least August 2026. The breadth of alternative solutions and ongoing federal process underscores why the FCC should not prematurely reconfigure the Lower 900 MHz Band around one company's preferred solution when less disruptive PNT approaches are available and already under evaluation.

The undersigned associations and organizations collectively represent the technology, retail, electricity, oil and natural gas, commercial and civil aviation, security, and manufacturing sectors of the American economy, industries that together employ tens of millions of Americans, power critical infrastructure, and drive the supply chains on which consumers depend every day. Nearly 2,000 comments have been filed in this proceeding, with only a handful supporting NextNav's proposal. The breadth and depth of this opposition is not coincidental. It reflects the simple reality that NextNav's proposal would impose largely irreversible harm on the American economy in exchange for speculative benefits that can be achieved through other means, at lower cost. We respectfully request that the Commission dismiss NextNav's Petition for Rulemaking and pursue technology-neutral, multi-solution approaches to PNT resilience that do not sacrifice the Lower 900 MHz Band ecosystem.

Sincerely,

Aerospace Industries Association (AIA)
AIM Global
Airlines for America
Air Line Pilots Association (ALPA)
Alarm Industry Communications Coalition
American Gas Association
American Petroleum Institute
American Trucking Associations
Association of Uncrewed Vehicle Systems International (AUVSI)
California Alarm Association
California Trucking Association
Cargo Airline Association
Commercial Drone Alliance (CDA)
Computer & Communications Industry Association (CCIA)
Consumer Technology Association (CTA)

¹⁷ Federal Communications Commission, *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, Notice of Inquiry, WT Docket No. 25-110 (adopted Mar. 27, 2025).

¹⁸ U.S. Department of Transportation, *Complementary Position, Navigation, and Timing (CPNT) Services Rapid Phase II*, <https://sam.gov/opp/396f1fle901a4155ace2263e3c70a588/view> (last visited June 3, 2026).

¹⁹ U.S. Department of Transportation, *Executing Rapid Phase of the U.S. DOT Complementary Positioning, Navigation, and Timing Action Plan: One Step Closer to User Adoption*, <https://www.volpe.dot.gov/news/executing-rapid-phase-us-dot-complementary-positioning-navigation-and-timing-action-plan-one> (last visited May 28, 2026).

Dynamic Spectrum Alliance
E-ZPass
Edison Electric Institute
Electronic Security Association
FMI - The Food Industry Association
General Aviation Manufacturers Association
GPS Innovation Alliance (GPSIA)
GS1 US
Illinois Trucking Association
Information Technology Industry Council (ITI)
International Bridge, Tunnel and Turnpike Association (IBTTA)
Interstate Natural Gas Association of America
Iowa Motor Truck Association
Kentucky Trucking Association
Louisiana Motor Transport Association
Maryland Motor Truck Association
Minnesota Trucking Association
Missouri Trucking Association
Montana Trucking Association
National Association of Manufacturers
National Retail Federation
Nevada Trucking Association
New Jersey Motor Truck Association
North Carolina Trucking Association
Ohio Trucking Association
Pennsylvania Motor Truck Association
PrePass Safety Alliance
RAIN Alliance
Regional Airline Association
Retail Industry Leader's Association
Rhode Island Trucking Association
Security Industry Association
Software & Information Industry Association (SIIA)
South Carolina Trucking Association
TechNet
Telecommunications Industry Association (TIA)
Tennessee Trucking Association
Texas Trucking Association
Thales Group
The Monitoring Association
Trucking Association of New York
U.S. Chamber of Commerce
Vertical Aviation International
WI-FI Alliance
WifiForward

cc:

The Honorable Brett Guthrie, Chairman, House Committee on Energy and Commerce
The Honorable Frank Pallone, Ranking Member, House Committee on Energy and Commerce
The Honorable Richard Hudson, Chairman, Subcommittee on Communications and Technology
The Honorable Doris Matsui, Ranking Member, Subcommittee on Communications and Technology
The Honorable Ted Cruz, Chairman, Senate Committee on Commerce, Science, and Transportation
The Honorable Maria Cantwell, Ranking Member, Senate Committee on Commerce, Science, and Transportation
The Honorable Deb Fischer, Chair, Subcommittee on Telecommunications and Media
The Honorable Ben Ray Lujan, Ranking Member, Subcommittee on Telecommunications and Media
The Honorable Pete Hegseth, Secretary of War
The Honorable Howard Lutnick, Secretary of Commerce
The Honorable Sean Duffy, Secretary of Transportation
The Honorable Chris Wright, Secretary of Energy
The Honorable Laura Swett, Chairman of the Federal Energy and Regulatory Commission
The Honorable Arielle Roth, Administrator, National Telecommunications and Information Administration
The Honorable Anna M. Gomez, Commissioner, Federal Communications Commission
The Honorable Olivia Trusty, Commissioner, Federal Communications Commission

THE
**BULL
MOOSE**
PROJECT

June 2, 2026

Office of Congressman Richard Hudson
2112 Rayburn House Office Building
Washington, D.C.
20515

Office of Congressman Frank Pallone
2107 Rayburn House Office Building
Washington, D.C.
20515

Office of Congressman Brett Guthrie
2161 Rayburn House Office Building
Washington, D.C.
20515

Office of Congresswoman Doris Matsui
2206 Rayburn House Office Building
Washington, D.C.
20515

Dear Chairman Rep. Guthrie, Chairman Rep. Hudson, Ranking Member Rep. Pallone, and Ranking Member Rep. Matsui:

I write to commend you for your decision to hold the upcoming hearing, "Where Are We?: Examining Positioning, Navigation, and Timing Capabilities in the United States." As the world becomes more uncertain and the global order shifts in new and unpredictable ways, we at the Bull Moose Project believe it is imperative that Americans – those who serve in the government, the military, and those who are just trying to visit their families – know that our country has positioning systems that they can trust.

In the search to provide backups to GPS, it's important to underline that GPS is not in itself a poor technology. It has served Americans well, be it on trips to the beach or in combat. But relying solely on GPS in the future would be a mistake, as it is relatively easy to disrupt or even cripple these systems. Which is why we advocate for a "layered" architecture, or system of systems, where 5G acts as the resilient, un-spoofable terrestrial complement to GPS. As a litany of news stories over the past few years – from airport shutdowns to delayed agricultural production to drone warfare in Ukraine – have demonstrated, the need for alternatives is not a hypothetical.

As detailed in our October 2025 report, "Leaping Ahead: Securing America's Future with a 5G-Based Backup to GPS," our adversaries (Russia, China, Iran, and North Korea) have already deployed terrestrial, layered PNT redundancies. By failing to provide a similar ground-based complement, the U.S. has effectively left its critical infrastructure, from the electric grid and banking to precision agriculture, exposed to electronic warfare.¹

¹ "Leaping Ahead: Securing America's Future with a 5G-Based Backup to GPS: Why the U.S. Must Outpace China in PNT Resilience and Break the Gridlock Which Endangers Our National Security," Bull Moose Project, October 7, 2025,

THE
**BULL
MOOSE**
PROJECT

To that end, we write to draw your attention to one particular Position, Navigation, and Timing alternative to GPS, one which already has key aspects of its technology around the United States: 5G.

Ever since the National Timing Resilience and Security Act was passed in 2018, there have been discussions as to what sort of terrestrial alternative should be created. But 5G makes perfect sense because it's *already here*. Private companies have an incentive to build 5G networks, as their own systems already rely upon it. A 5G-based system would be extraordinarily effective at reaching Americans. because 5G is already effective at doing so: 99 percent of Americans are covered by 5G networks.² Plus, as our president, Aiden Buzzetti, recently argued in a comment to the Federal Communications Commission, private industry has already deployed towers meaning the system would not cost taxpayers a penny.³

The creation of a PNT alternative slices across a variety of sectors – from infrastructure to national security to tech – making it a thorny and difficult issue. By greenlighting terrestrial PNT, the FCC can foster a new market for "precision" services, ensuring the U.S. remains the global leader in PNT innovation.

We applaud Chairman Carr's recent actions at the FCC to launch a proceeding to explore these vital PNT complements. We further urge this Committee to support a rapid, private-sector-led rollout of backups to ensure that Americans have a navigation system they can trust if and when GPS goes dark.

Sincerely,

Aiden Buzzetti
President
Bull Moose Project

https://static1.squarespace.com/static/62a0e720703c0124c51f3a7f/t/68e3d9ae85f07b1d0133fdd9/1759762862081/BMP_5G+Based+Back-Up+Report.pdf.

² Viet Nguyen, "U.S. Nears Universal 5G Adoption as North America Leads the World," 5G Americas, December 11, 2025,

<https://www.5gamericas.org/u-s-nears-universal-5g-adoption-as-north-america-leads-the-world>.

³ Aiden Buzzetti, "Comment of The Bull Moose Project," in *Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions*, WT Docket No. 25-110, Federal Communications Commission, October 9, 2025,

<https://static1.squarespace.com/static/62a0e720703c0124c51f3a7f/t/68e6c193a00ffd1e5838cdf9/1759953299164/BMP+PNT+Filing.pdf>.

June 3, 2026

The Honorable Richard Hudson
Chair
Subcommittee on Communications and
Technology

The Honorable Doris O. Matsui
Ranking Member
Subcommittee on Communications and
Technology

Chairman Hudson, and Ranking Member Matsui,

The Information Technology and Innovation Foundation (ITIF) commends the subcommittee for convening a hearing on the important topic of Positioning, Navigation, and Timing Capabilities.¹ This hearing is timely as the United States seeks to secure PNT systems and evaluate proposals for alternative and redundant PNT systems.

ITIF supports the goal of backup PNT systems, but we write to caution against setting up any particular proposal as synonymous with that goal. Specifically, NextNav's proposal for the FCC to unilaterally grant it greater rights at the expense of other users of the 900 MHz band is not in the public interest.

NextNav understates the complexity of its proposal. Its implementation would not be a simple case of repackaging a few incumbents and filling up formerly fallow spectrum with contiguous, flexible-use licenses. On the contrary, a diverse universe of devices occupies the band, many of which are Part 15 devices that are not under the control of any Commission licensee. These extensive uses are by retailers, utilities, Internet of Things networks for everything from agriculture to oil and gas extraction, and amateur radio operators.²

¹ Founded in 2006, ITIF is an independent 501(c)(3) nonprofit, nonpartisan research and educational institute—a think tank. Its mission is to formulate, evaluate, and promote policy solutions that accelerate innovation and boost productivity to spur growth, opportunity, and progress. ITIF's goal is to provide policymakers around the world with high-quality information, analysis, and recommendations they can trust. To that end, ITIF adheres to a high standard of research integrity with an internal code of ethics grounded in analytical rigor, policy pragmatism, and independence from external direction or bias. See About ITIF: A Champion for Innovation, <https://itif.org/about>; "Chairmen Guthrie and Hudson Announce Hearing on Positioning, Navigation, and Timing Capabilities." House Committee on Energy and Commerce, May 28, 2026. <https://energycommerce.house.gov/posts/chairmen-guthrie-and-hudson-announce-hearing-on-positioning-navigation-and-timing-capabilities>.

² Mark Roberti, "Impinj CEO: RAIN RFID Industry Must Oppose Proposed Changes to 900 MHz Frequency Band," RFID Journal, February 17, 2024, <https://www.rfidjournal.com/editors-views/impinj-ceo-rain-rfid-industry-must-oppose-proposed-changes-to-900-mhz-frequency-band/221538/>; Cambium Networks, "Wireless Solutions for Oil, Gas, and Utility Industries" (Cambium Networks, January 16, 2018), <https://www.cambiumnetworks.com/wp->

While NextNav may question whether these users are the most productive possible, its conclusory claim that the band is in fact underutilized understates the technical and policy barriers to realizing its proposal.³

NextNav's proposal would also come at the expense of other users with interference protection rights guaranteed by Federal Communications Commission rules. This band is somewhat unusual in that FCC rules give rights to Part 15 devices in this band that distinguish them from run-of-the-mill unlicensed devices.⁴ NextNav's proposed changes to the Code of Federal Regulations would eliminate its existing obligations to protect Part 15 devices from "unacceptable interference" and the safe harbor for certain Part 15 devices.⁵ That NextNav's proposal would require this change is evidence that Multilateration Location and Monitoring Service (M-LMS) users are not simply primary licensees such that unlicensed devices must accept all their interference and never cause harmful interference. Rather, it is sometimes the "unlicensed" devices that have interference protection from M-LMS and M-LMS that must sometimes accept what would otherwise be harmful interference. In such cases, NextNav's proposal is unlike one in which a licensee seeks to remove legacy restrictions on an exclusive license, and it is more like a secondary user seeking to expand its rights at the expense of users who currently own some degree of priority and legal protection. The Commission should not unilaterally transfer other parties' legal rights to NextNav.

If NextNav is right that its proposal can increase the productivity of the band without harming existing users it has a legal obligation to protect, then it should be able to come to a voluntary agreement. Indeed, NextNav has suggested it is willing to "work with Lower 900 MHz Band incumbents, including federal, ISM, and non-M-LMS, amateur, and unlicensed."⁶ That kind of work could be an invaluable contribution to spectrum productivity. If successful, these arrangements would allow NextNav to do all that it asks for in its petition without relying on the FCC to force all existing users to hand over rights for which NextNav could bargain.

Policymakers are right to seek to enable more resilient PNT services. There is nothing special about the NextNav proposal or the 900 MHz band in general that necessitates its use toward that goal. Thank you for your consideration.

[content/uploads/2017/03/BR_oilGasUtilities_01162018_pages.pdf](#); QRZ Forums, "Could We Lose Amateur Radio on 900 MHz? Breaking NPRM News," <https://forums.qrz.com/index.php?threads/could-we-lose-amateur-radio-on-900mhz-breaking-nprm-news.925041/>.

³ Petition for Rulemaking of NextNav Inc., (April 16, 2024) 6-7

<https://www.fcc.gov/ecfs/document/10416238018537/1>.

⁴ 47 C.F.R. §§ 90.353(d), 90.361

⁵ Letter from NextNav Inc. to Marlene H. Dortch (June 7, 2024) A-4 (proposing to strike 47 C.F.R. § 90.353(d) and the safe-harbor provisions of § 90.361) <https://www.fcc.gov/ecfs/document/10607137757430/1>.

⁶ Petition at 30.

Sincerely,

Joe Kane
Director of Broadband and Spectrum Policy
Information Technology and Innovation Foundation



June 2, 2026

The Honorable Richard Hudson
Chairman
Communications & Technology Subcommittee
U.S. House Committee on Energy & Commerce
Washington, D.C. 20515

The Honorable Doris Matsui
Ranking Member
Communications & Technology Subcommittee
U.S. House Committee on Energy & Commerce
Washington, D.C. 20515

Dear Chairman Hudson and Ranking Member Matsui,

Thank you for holding a hearing to consider the status of, and challenges facing, the deployment of positioning, navigation, and timing (PNT) alternatives to the U.S. Global Positioning System (GPS). This is a vital issue with serious national security concerns. As Congress builds a record on this important debate, I am writing you today on behalf of the American trucking industry to express concerns over the potential reallocation of broadband spectrum that would disrupt multiple every-day use cases for trucking, which would reduce supply chain visibility, decrease the efficiency of freight movement, and impede effective highway safety enforcement.

Trucking is the lifeblood of our economy. Trucks move over 72 percent of our nation's freight by tonnage and are the sole source of freight service for 80 percent of American communities. The industry employs 8.4 million individuals, including 3.6 million commercial truck drivers. Over 90 percent of America's trucking companies operate ten trucks or fewer, and these fleets are typically generational, mom-and-pop trucking companies. The American Trucking Associations (ATA) is a fifty-state federation that represents trucking fleets of all sizes and specializations serving every sector of our nation's economy and the key service providers that help those businesses grow and compete.

The Lower 900 MHz band (902-928 MHz) currently enables communication between licensed and unlicensed devices that are used by trucking companies of all sizes for a variety of purposes. RFID tags and devices help to track inventory and equipment throughout the supply chain, bypass congested tolling plazas at highway speeds, and communicate with law enforcement to enable weigh-station bypasses that increase the efficiency of vehicle inspections.

Trucking companies, their service-provider partners, law enforcement, and toll authorities have made billions of dollars in combined investments in technologies that utilize the Lower 900 MHz band in ways that reduce highway congestion, speed the movement of freight, increase safety, and improve supply chain visibility. A key driver of these investments has been the low cost to deploy unlicensed devices for new and innovative purposes. This framework has led to scalable applications, significant adoption, and substantial value for freight and logistics companies within the current use cases of the Lower 900 MHz Band. Ultimately, these benefits result not just in safer roads, but also in lower prices for American consumers.

The benefits of PNT alternatives need to be weighed against the costs they would impose on American citizens. The NextNav alternative to PNT would deploy high-power devices within this Lower 900 MHz Band that could significantly disrupt incumbent users, especially RFID. The NextNav alternative has not yet been thoroughly proven to avoid disruption of existing devices in freight and logistics that are vital to

the functionality of our nation's critical infrastructure and general wellbeing of Americans. Without stringent testing, deployment of these technologies could potentially wreak havoc on our nation's supply chains—creating national security concerns and economic disruption that the search for GPS alternatives is striving to avoid.

ATA strongly opposes any proposal that would disrupt current use cases for the Lower 900 MHz Band. Before any action is taken, thorough, independent, and transparent research is needed to determine whether the goals of a PNT alternative involving the Lower 900 MHz Band can be achieved while protecting the critical applications that are vital to American supply chains.

As the largest national trade organization representing the men and women working in the trucking industry, ATA stands ready to work with Congress on this important issue. We look forward to supporting the Committee's efforts to strengthen national security and resilience without disrupting our critical supply chains. Thank you for your leadership.

Sincerely,

A handwritten signature in black ink, appearing to read 'H. Hanscom', with a long horizontal flourish extending to the right.

Henry Hanscom
Chief Advocacy and Public Affairs Officer
American Trucking Associations

Cc: The Honorable Brett Guthrie, Chairman, House Committee on Energy & Commerce
The Honorable Frank Pallone, Ranking Member, House Committee on Energy & Commerce



June 2nd, 2026

The Honorable Brett Guthrie
Chairman, House Committee on Energy and Commerce
U.S. House of Representatives

The Honorable Richard Hudson
Chairman, Subcommittee on Communications and Technology
U.S. House of Representatives

cc: Ms. Lauren Hodge, Chief of Staff to Chairman Guthrie
Ms. Alex Rosemond, Chief of Staff to Chairman Hudson

Subject: Support for Your Leadership on Positioning, Navigation, and Timing Capabilities and the Path to a Comprehensive Intelligent Infrastructure Executive Order

Dear Chairmen Guthrie and Hudson:

Thank you for your leadership in announcing the June 4 hearing, “Where Are We?: Examining Positioning, Navigation, and Timing Capabilities in the United States.” Your focus on strengthening PNT resilience is timely and essential. GPS underpins national defense, critical infrastructure, financial systems, energy grids, and the emerging low-altitude economy. A whole-of-government approach that harnesses private-sector innovation is exactly what is needed to counter adversarial gains and secure America’s technological edge.

America already possesses the core technologies—mature autonomous platforms (drones, eVTOLs, ground vehicles), advanced sensors, detect-and-avoid systems, secure command-and-control, and spectrum solutions. What has been missing for more than two decades is a scalable, investable business model capable of unlocking the tens of billions in private capital required to move from pilots and demonstrations to nationwide, economically sustainable deployment.

Intelligent Infrastructure Economic Zones (IIEZ) provides that missing model. Developed over seven years with a coalition of thousands of collaborators and hundreds of partners, IIEZ creates a public-private framework that cuts through the implementation barriers that have limited prior Executive Orders. It delivers the physical layer—edge computing, resilient communications, precise PNT, active digital twins, and multi-modal orchestration—needed for Physical AI, automated mobility districts, resilient supply chains, and a thriving low-altitude economy.

Your leadership on PNT positions the Energy and Commerce Committee, and especially the Communications and Technology Subcommittee, at the center of efforts to deliver a practical solution. An Intelligent Infrastructure Executive Order, grounded in this proven deployment model, can finally translate the vision of multiple prior orders into measurable results: countering foreign PNT threats, attracting 10s of billions of sidelined private capital, creating high-skill jobs, and strengthening America’s technological sovereignty.

I would welcome the opportunity to brief you or your staff, provide detailed materials on the IIEZ model and coalition, or offer input for the hearing record. Our partners stand ready to support your efforts to make the United States the global leader in secure, resilient positioning, navigation, and timing



infrastructure. Advancing Intelligent Infrastructure to build America's Next Golden Age.

Thank you again for your vision and commitment. I look forward to supporting your important work.

With respect and shared vision,

Jeffrey DeCoux
Chairman, Autonomy Institute
CEO, ATRIUS Industries

On Behalf of the Intelligent Infrastructure Community of Interest, Continuum of Capital Alliance
A Coalition of Engineers, Scientists, Military Generals, Infrastructure Investors, and Civic Leaders.

Just two words: Intelligent Infrastructure. *The digital backbone of America's next economy—without it, resilience, autonomy, growth, and shared prosperity remain just ideas.*



The White House, the U.S. Department of Transportation, the United States Department of Commerce, the U.S. Department of Homeland Security, the Federal Highway Administration, and the United States Department of War across different administrations and legislative bodies have consistently championed Intelligent Infrastructure for decades.

- "Secure 5G networks will absolutely be a vital link to America's prosperity and national security in the 21st century. President Donald Trump
- "Industrial policy is needed. That includes establishing independence on . . . Intelligent Infrastructure." Jamie Dimon, Chairman and CEO of JPMorganChase
- "Deploying 5G networks is also vital to America's global competitiveness." Senator Ted Cruz (R-TX)
- Intelligent Infrastructure could be our century's economic equivalent of the transcontinental railroad. Larry Fink, Chairman & CEO, BlackRock
- "5G is about building an Industrial Internet that provides for automation - autonomous systems and Industry 4.0." General Rob Spalding
- "The marriage of technology and infrastructure is the most attractive. With an Intelligent Highway you have multiple revenue sources." William T. Nolan, Federal Infrastructure Bank
- "The Pendulum is swinging, Edge is a force of decentralization". Pat Gelsinger, Former CEO of Intel
- "Over 75% of data will be processed at the Edge." Michael Dell, Chairman and CEO of Dell
- "We see that the vast majority of the data is created at the Edge, where we live and work." John Chambers, Former CEO of Cisco
- "Connectivity has to become an essential service, no different than water and electricity." Antonio Neri, Chairman and CEO of HPE
- "Data is the new oil, which means it will be where nation states compete". Roger McNamee, Elevation Partners
- "The U.S. needs a cohesive strategy for the safe deployment of next-generation wireless technologies." Senator Roger Wicker (R-MS)
- "Intelligent Infrastructure will allow us too quickly achieve practical signal densification . . . to enable a new industrial economy." Nathan Simington, FCC Commissioner
- "Ensuring the United States remains a leader in next-generation communications has long been a priority of mine." Senator John Thune (R-SD)
- "To achieve game-changing beneficial outcomes, governments and industry must work together." Senator Mark Warner (D-VA)
- "Spectrum is invisible infrastructure; we may not be able to see it, but it is where we are going to build our economic future". Chairwoman Jessica Rosenworcel
- "Our economic and national security depend on the United States remaining the leader in wireless technology." Representative Tim Walberg (R-MI)
- "The race to 6G isn't just about faster phones - it's about national security, economic security and America's standing on the international stage." Representative Doris Matsui (D-CA)
- "We've got to promote American competitiveness in these kind of cutting-edge technologies." Senator Catherine Cortez Masto (D-NV)
- "Much like what we are finding in the military, we need a commercial variant of an Intelligent Infrastructure that is highly secure but upgradeable." Bruce Jette, Former Assistant SECDEF of Army



Executive Summary: The "North Star" for National Digital Infrastructure

America's primary barrier to global leadership in Intelligent Transportation, AI, NextG, and autonomous systems is not technology—it is the absence of a business model capable of unlocking the tens of billions in private capital required by Intelligent Infrastructure. Without a defined North Star (i.e. Intelligent Infrastructure Commerce & Defense Act), we remain in an infrastructure nightmare of action without vision. The fastest path to dominance is to immediately authorize large-scale deployments of Intelligent Infrastructure Economic Zones. By underwriting this physical backbone now, we provide the platform for Industry 4.0 and secure American sovereignty for the next century.

The U.S. Department of Transportation stands at a critical and historic precipice. For over 20 years, the United States has struggled to deploy a cohesive, national Intelligent Transportation System (ITS) at a scale commensurate with our economic potential and technological prowess. We have witnessed a systemic failure to keep our national broadband evergreen, a chronic lack of densification in low-altitude sensors, and the persistent absence of a robust national M2M fabric. Furthermore, our inability to deploy a reliable terrestrial alternative to GPS—an essential requirement for Assured Positioning, Navigation, and Timing (APNT)—has left our civil and defense systems vulnerable to interference. We have also failed to modernize our electrical grids with true edge intelligence, leaving our most basic utility services vulnerable to rising AI demand and cyber threats.

The cascading costs of this infrastructure delay are not merely statistical; they are catastrophic. Over the past two decades, this stagnation has contributed to over one million preventable deaths on our roadways and more than 50 million life-altering injuries. The economic toll is estimated at a staggering \$10 trillion in cumulative loss, accompanied by over \$100 billion in bankruptcies of innovative U.S. companies as industries fail to navigate the "Dumb Infrastructure" friction. This stagnation has directly ceded the technological high ground to international competitors, specifically through China's "Belt and Road" and "Military-Civil Fusion" initiatives. These adversaries prioritize edge connectivity not just as a convenience but as a strategic tool for geopolitical dominance.

As wise men have stated, vision without action is a dream, but action without a unified vision is the nightmare we are currently experiencing—a fragmented landscape of isolated pilot programs and "science projects" that never reach the finish line of scaled, national deployment.

Industry leaders have identified that we are currently entering the largest capital deployment cycle in the history of technology. "The cloud built the digital economy. Intelligent Infrastructure will build the physical one."

"The backbone of the world is changing, the digitization of the physical world." "Historically, infrastructure was built out by governments; today, it's being built out by private enterprises."
Bruce Flatt, CEO of Brookfield

No single federal agency or industry currently possesses a business model capable of enabling the large-scale convergence required for this buildout. Intelligent Infrastructure Economic Zones are the decisive policy innovation that cuts the Gordian Knot of local regulation and fragmented easement rights, transforming the U.S. from a perpetual laggard into the undisputed leader in NextG and AI-RAN deployment.



JFK and Eisenhower set the mission for their eras with absolute clarity, knowing that the specific engineering hurdles would only be cleared once a definitive "North Star" was established. For the 21st century, that North Star is **Intelligent Infrastructure**.

I. The Business Model: Intelligent Infrastructure Economic Zones (IIEZ)

The primary barrier to a national Transportation Digital Infrastructure (TDI) has never been a lack of technological ingenuity; it has been the absence of a business model capable of supporting the massive, multi-sector convergence of civil, commercial, and national defense requirements. The Autonomy Institute has solved this structural deadlock through the creation of **Intelligent Infrastructure Economic Zones (IIEZ)**.

- **Bridging the Civic & Market Economy:** IIEZs provide the foundational business model that allows for the simultaneous, multi-tenant deployment of broadband, NextG wireless (5G/6G), the FAA NextGen air traffic system, and the DoD Golden Dome. This convergence refactors the physical environment into a responsive platform for Autonomy 2.0, turning depreciating road assets into revenue-generating intelligent corridors. By establishing these zones, we allow infrastructure to move beyond "tolls and taxes" and into "data monetization and spectrum leasing."
- **The Continuum of Capital:** Physical infrastructure requires capital mobilization far beyond traditional venture capital models, which are often inadequate for the massive, long-term cycles of the physical world. The "Continuum of Capital" leverages an innovative hybrid structure—merging Master Limited Partnerships (MLPs) with Real Estate Investment Trusts (REITs) to create the **Master Infrastructure PINN Partnership (MIPP)**. This creates a new industry asset class that offers stable, long-term returns leveraged from asset leases and data throughput. This model has already mobilized the interest of private titans like Bruce Flatt (Brookfield), Jamie Dimon (JPMorgan Chase), and Larry Fink (BlackRock). With JPMorgan Chase's \$1.5 trillion focus on Intelligent Infrastructure, the private sector is ready to underwrite the national buildout if the regulatory environment permits it.
- **The Public-Private Synergy:** While private capital must lead the buildout to ensure speed and efficiency, the Federal government remains the essential catalyst. By providing grants and programs that offset initial capital expenses (CapEx) and providing regulatory certainty through fast-track permitting, the public sector can enable the private sector to scale rapidly across the 1.5 million nodes required for a truly resilient national network. Federal and state agencies should shift their focus from "owning and operating" complex technology to "setting standards and facilitating" private deployment.





II. Technical Foundation: "Smart Cities, Dumb Infrastructure"

To ensure an orderly and competitive national buildout, the USDOT must embrace a "passive infrastructure" model. Brent Skorup in his seminal research. The most efficient path to identifying and solving R&D challenges is to separate the long-lasting, reliable "Dumb Infrastructure" from the rapidly evolving "Smart" technology it houses. This prevents "technology lock-in" where public funds are wasted on devices that become obsolete within months.

1. **Passive Infrastructure Assets:** The focus of TDI should be the deployment of **Public Infrastructure Network Nodes (PINNs)**—the physical "wellheads" of the data economy. These modular, sleek units are installed along city sidewalks, master-planned communities, and highways to provide the essential "Dumb" foundation: power, fiber, and precise spatial positioning. They are designed to support 30+ years of hardware and software upgrades without requiring constant, costly street excavations or "strapping and bolting" random devices to existing light poles.
2. **Open Access & Competition:** Following the "policy-induced competition" model, we must manage the PINNs as "dumb" (passive) assets to ensure an open-access environment. This prevents the vertical exclusion that has historically stifled the innovation flywheel. When the infrastructure is an open utility, multiple service providers—ranging from Drone-as-a-First-Responder (DFR) and Mobility-as-a-Service (MaaS) to AI-RAN operators—can compete on a level playing field, driving down costs for the consumer and increasing service quality.
3. **The Physical Internet:** We are witnessing the largest capital deployment cycle in history, not merely to connect people to the internet, but to connect every highway, city sidewalk, and community to intelligence. This creates a "system of systems" where the physical layer (the PINN) acts as the router for robotics, enabling safe and autonomous air and ground vehicle operations through ultra-low latency edge computing (<1ms).

III. National Priorities & Geopolitical Supremacy

The refactoring of our national backbone is a strategic necessity echoed daily by Secretary Duffy, Lutnick, Secretary Hegseth, and dozens of Senators. The TDI strategy must serve as the foundational policy equivalent of the 1956 Interstate Highway Act, securing our supply chains and industrial sovereignty.

- **AI-RAN & Sovereign Intelligence:** The convergence of AI and telecom at the edge is the most strategic foundation of our time. Refactoring how we manage spectrum and compute is essential to reclaiming American technological leadership and ensuring national security. A national AI-RAN platform provides a resilient, cognitive radio network that is vital for both civilian commerce and Department of Defense readiness.
- **Infrastructure for Robotics:** A national TDI must serve as the "Router for Robotics," providing the M2M RAN, Active Digital Twin, Precise Positioning, and Sovereign Data Exchange required for safe, autonomous air and ground vehicles. This infrastructure is the prerequisite for moving autonomous systems from the factory floor to the open road, unleashing a productivity boom that will secure our national supply chains against future disruptions.



- **A Modern Precedent:** J.P. Morgan advanced the electrification of the continent and David Rockefeller mobilized the private capital for Eisenhower's highways. Today's leaders are ready to do the same for a system that will drive our nation's productivity and push GDP past the 5% mark. By enacting a "Dig Once" policy and providing clear asset-class definitions for Intelligent Infrastructure, we can slash deployment costs by over 70%.

IV. AI-RAN is a National Priority - Alignment Executive Orders on Intelligent Infrastructure

Intelligent Infrastructure is a strategic imperative for national security and economic sovereignty, requiring dense, secure, and resilient wireless networks for both civilian and defense applications. Washington has released dozens of Executive Orders that support Intelligent Infrastructure, scaling drone operations, and securing American leadership for 6G and AI-RAN. Secretary Hegseth calls Intelligent Infrastructure the establishment of the American "nervous system for American power projection."

"For our country to reach the scale it can be, we need to be the leader in the world for 5G and 6G".
Howard Lutnick,
Secretary, US Department of Commerce

- **AI for the Physical World:** The combination of the Intelligent Infrastructure Economic Zone business model with AI-RAN will regain leadership for intelligent mobile networks. AI-RAN is a catalyst for the national buildout of Intelligent Infrastructure. It enables intelligent automation, network slicing, on-demand resource management, and distributed AI inference for applications in enterprise AI, public safety, and "AI for the Physical World."
- **All-American:** Industry leaders have emphasized building all-American, software-defined AI-RAN stacks to reduce reliance on foreign vendors and enable real-time AI intelligence at the network edge for operators, enterprises, and government agencies.
- **National Leadership:** The White House, USDOT, NTIA, DARPA, DoD, FAA, and Homeland Security have issued dozens of Executive Orders, initiatives, and national directives to ensure the United States regains dominance in 6G and advanced mobility, and continues leadership in AI and Silicon.



V. A Future Forged in Every Community

The greatest impact of I2 is human. It touches the day-to-day life of every citizen, reviving dignity, prosperity, and opportunity at the local level. Intelligent Infrastructure Economic Zones (I2EZ) will serve as catalysts, moving investment from distant data centers directly into our neighborhoods.

- **Revive Cities:** Drive job creation, urban revitalization, and enhanced connectivity.

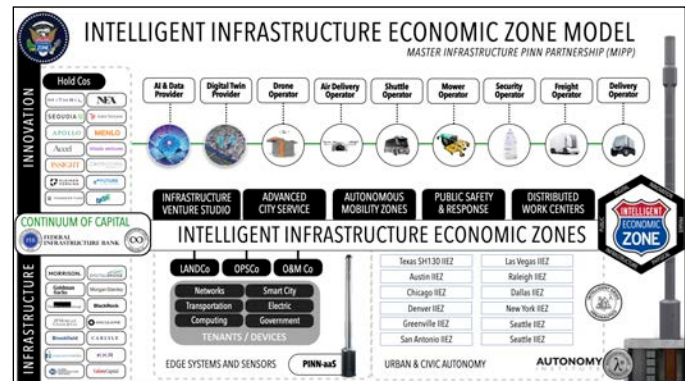


- Empower Families: Our national productivity depends on empowering individuals and families. These Economic Zones will revive respect for skilled trades and delivery by enabling technologies like Venture Studios and local AI clusters.
- Foster Unity: This bold mission, with critical projects underway in Texas, Ohio, Indiana, North Carolina, Oklahoma, Pennsylvania, and California (in preparation for the LA28 Olympics), requires national unity and collaboration across all regions.

VI. Operationalizing the Intelligent Infrastructure (I2), supporting Commerce & Defense

A National Security and Economic Priority. The deployment of 1.5 million PINNs over the next 5-7 years is not merely a commercial goal; it is a national mandate. Intelligent Infrastructure is the "North Star" for addressing critical priorities:

- Commerce: It enables new digital services, such as active digital twins, drone-as-a-first-responder, and resilient electrical grids, to support our manufacturing resurgence.
- Community: It enables evergreen broadband, sovereign AI data centers, and the community engagement foundation required for the data economy, unlocking data value while keeping it sovereign for the communities they serve. AI (and ethics) is all about Data
- Transportation: It is the physical infrastructure for the FAA NextGen and Intelligent Transportation Systems, guaranteeing precise positioning and Autonomy 2.0.
- Defense: I2 provides the real-time, resilient NextG for Civil and DoD, creating the "Golden Dome" for our warfighters.



VII. Conclusion and Call to Action

As we enter a new era of global technological competition, we must stop "building concrete plants without laying highways." This is not merely a research initiative; it is a strategic imperative for our national security, our supply chain resilience, and our economic sovereignty. We must mobilize the private sector to lead the buildout of Intelligent Infrastructure Economic Zones to allow the United States to compete and win in the 21st-century global economy.

We urge the U.S. DOT to adopt the IIEZ framework as the heart of the National TDI Strategy and help operationalize the Intelligent Infrastructure Community of Interest (COI).

The Autonomy Institute has a Community of Interest of over 3,000 collaborators, 400 partners, 2 decades of Presidential Executive Orders, and \$10s of billions in capital dedicated to Intelligent Infrastructure. This includes influential engineers and scientists, former military admirals & generals, national transportation leaders, Fortune-500 industry executives, published authors, and prominent civic leaders. America's future dominance hinges on one decisive mission: the immediate deployment of Intelligent Infrastructure (I2).



History is not merely inherited; it is built. In the 20th century, great men and women forged our nation's destiny through bold, unifying missions. They built the water systems that quenched our thirst, the electric grids that powered our industry, and the Interstate Highway System that connected our economy. They won the Space Race, securing decades of leadership in innovation.

Intelligent Infrastructure is our generation's Interstate Highways and will be a critical foundation for building our Next Golden Age. The new Administration has a directive for advanced NextG (5G/6G), focused on "commercial deployments," and Intelligent Infrastructure will speed the deployment of America's AI-RAN, which will be one of the most strategic foundations of our time, leading to the refactoring of how we manage spectrum and compute.

"United we build; divided we buy from abroad." . . . The capital is allocated. The technology is proven. The mandate is clear. It is time to build.

Respectfully Submitted,

Jeffrey DeCoux
CEO, ATRIUS Industries
Chairman, Autonomy Institute

On Behalf of the Intelligent Infrastructure Community of Interest, Continuum of Capital Alliance
A Coalition of Engineers, Scientists, Military Generals, Infrastructure Investors, and Civic Leaders.

Cc: Chris Stark, Former head of Nokia Strategy and BD, developed CBRS
William T. Nolan, Federal Infrastructure Bank
Dr. Andrew Heller, Technology Advisor
Ted Miller, Founder and former CEO of Crown Castle
Mark Bigham, Former Chief Innovation Officer of Raytheon
Shawn Tyrie, President of McChrystal Group Government
Michael Shear, CEO of Strategic Office Networks, LLC
Patricia Baumhart, Emerging technologies executive
Kent O'Brien, Decades of Engineering Transportation Infrastructure
Richard Mudge, Transportation Economics and Finance
Jeoff William, Former Deputy Director of Texas DPS

It isn't that they can't see the solution. It is that they can't see the problem. G.K. Chesterton

June 4, 2026

The Honorable Brett Guthrie
Chairman
Committee on Energy and Commerce
United States House of Representatives

The Honorable Frank Pallone, Jr.
Ranking Member
Committee on Energy and Commerce
United States House of Representatives

The Honorable Richard Hudson
Chairman
Subcommittee on Communications and
Technology,
Committee on Energy and Commerce
United States House of Representatives

The Honorable Doris Matsui
Ranking Member
Subcommittee on Communications and
Technology,
Committee on Energy and Commerce
United States House of Representatives

RE: June 4, 2026, Hearing - Where Are We?: Examining Positioning, Navigation, and Timing Capabilities in the United States

Dear Chairman Guthrie, Ranking Member Pallone, Chairman Hudson and Ranking Member Matsui,

On behalf of the Damage Prevention Action Center (DPAct), I am writing in connection with today's hearing to ask the Committee to consider the critical importance of GIS mapping as it relates to preventing damage to critical underground infrastructure. DPAct is a coalition of energy, utility, construction and infrastructure stakeholders whose mission is to advocate for public policies and industry practices that protect underground utility infrastructure and those who work and live near these vital assets.¹

OVERVIEW: Excavation-Related Damages to Buried Infrastructure Are Increasing

According to data compiled by the Common Ground Alliance, excavation damage remains one of the leading causes of infrastructure service disruptions nationwide, resulting in hundreds of thousands of reported dig-ins annually spanning all utility sectors. Furthermore, third-party utility strikes cost the U.S. economy over \$30 billion each year.²

¹ Damage Prevention Action Center members: <https://damagepreventionactioncenter.com/members/>

² Data from the Common Ground Alliance, a non-profit organization leading efforts to reduce damages to underground utilities in North America through shared responsibility among all stakeholders. Visit www.commongroundalliance.com.

CGA's 2024 DIRT Report highlights that excavation-related damages to buried utilities are moving in the wrong direction. The CGA Index — which tracks year-over-year damage trends — continues to rise, reflecting the rise in construction, infrastructure investments and ultimately, increasing damages to underground utilities and pipelines. Nearly 200,000 unique damage incidents were reported, and an underground utility is struck on average once every three minutes in the U.S. Each incident carries a wide range of consequences from service and economic interruptions to injuries and fatalities.

Compounding this challenge, excavators face an average 38% chance of being unable to start work on time due to incomplete locate responses. When the 811 process is unpredictable, excavator confidence erodes — potentially contributing to the leading root cause of damage: failure to notify 811 before digging.

Accurate maps of underground infrastructure are the foundation of the damage prevention process. When facility records are incomplete or inaccessible, even the most diligent locators and excavators are working against the odds. Improving mapping accuracy and expanding access to facility records aren't peripheral concerns; they are central to reducing damages attributed to locate failures and are vital to restoring confidence in the 811 process at every level.

CHALLENGE: The Mapping Gap

According to CGA's DIRT Report, failure to locate accurately and on time was the root cause attributed to 34% of damages to underground utilities. CGA's Locator White Paper and the findings of the Next Practices Initiative reveal that improving the accuracy of facility maps and implementing electronic whitelining would help locators complete their work more quickly and accurately. Records of underground utilities are often inaccurate or incomplete and are largely unavailable to damage prevention stakeholders like designers, locators and excavators. Advancing underground utility mapping and enabling appropriate accessibility to damage prevention stakeholders has the potential to significantly reduce damages and increase the efficiency of the safe excavation process nationwide.

Additionally, excavators continue to emphasize the importance of greater access to mapping records. The results of a 2024 national survey of excavators conducted by CGA revealed that 89% of professional excavators believe that having access to utility maps would reduce excavation damage.

OPPORTUNITY: Improved Facility Mapping Records

Although there is still a gap in mapping record accuracy and availability, many stakeholders are implementing programs and initiatives to improve their mapping records. Featured in CGA's Leadership in Mapping video series, Jerry Schmitz, VP of Safety & Quality for Southwest Gas, describes his company's commitment to using maps as the foundation for its asset management and damage

prevention efforts. Consumer's Energy implemented a program to map its own natural gas distribution pipelines in addition to sewer facilities in close proximity to those assets.

In California, Senate Bill 865 (SB 865), introduced and passed in 2020, took the improvement of mapping records further by requiring that new installations be mapped using GIS. The legislation aims to enhance safe excavation practices in the state by requiring all new subsurface installations as of January 1, 2023, to be mapped using a GIS except for specific oil and gas flowlines within oil fields.

Increased availability and accessibility of GPS-enabled locating devices is also providing the industry with greater opportunities to effectively map facilities.

UtiliSource, a Missouri-based utility design, engineering and project management company, rolled out a program to record the location of all third-party locates throughout a fiber installation project. They will then be able to utilize this mapping record as they continue to do work in the same area, improving future project efficiency and safety.

Gopher State One Call's GPS-enabled locator program in Minnesota partners with locating technology providers to equip damage prevention stakeholders across the state with utility line locators integrated with RTK GNSS accuracy and GPS collection capabilities. This program has been particularly beneficial to small municipalities, for whom updating legacy paper maps can be prohibitively time-consuming and expensive.

CONCLUSION: Accurate, reliable, and resilient GPS capability is central to mapping underground utilities, which is essential for protecting that infrastructure from excavation damage

We applaud the Committee for highlighting the important role that mapping plays in protecting our nation's critical infrastructure. Improved subterranean utility mapping can significantly reduce costly and dangerous dig-ins to buried infrastructure, enhance the current 811 process, and focus the industry on taking damage prevention to the next level. These advancements are essential to keeping our communities safe and connected to the utilities we depend on every day.

Sincerely,



Sarah K. Magruder Lyle
Executive Director
Damage Prevention Action Center



ITI Promoting Innovation Worldwide

April 1, 2026

The Honorable Howard Lutnick
U.S. Department of Commerce
1401 Constitution Ave NW
Washington, DC 20230

Dear Secretary Lutnick,

Robust and reliable Positioning, Navigation, and Timing (PNT) information is critical to U.S. national security and our economy. We strongly support the U.S. government exploring effective and resilient complements to the Global Positioning System (GPS). To ensure long-term success and adaptability, the U.S. government should pursue technology-neutral solutions that promote innovation and foster a competitive environment for evolving PNT capabilities. Importantly, this approach should build on, not disrupt, the existing spectrum environment that already supports widespread innovation across industries.

ITI has significant concerns about NextNav Inc.'s pending petition to reconfigure the 902–928 MHz band for an exclusive, nationwide 15 MHz flexible-use license for high-power, 5G-based location services. This type of reconfiguration would upend a robust spectrum ecosystem that currently enables a wide range of innovative technologies and services, in favor of selecting one particular technology over all others to supplement GPS. ITI believes granting this request would not only confer an unfair competitive advantage to a single technology provider but also interfere with a healthy innovation ecosystem and pose existential risks to existing users in this band.

The 900 MHz band is integral to the operation of key sectors including transportation, utilities, agriculture, security, public safety, supply chain, and logistics. Devices in these sectors depend on the band's existing configuration for reliable, interference-free operations, ranging from carbon monoxide detectors, fire alarms, and fall detectors for the elderly to tolling equipment and utility management systems. NextNav's proposal to reconfigure the band would generate tremendous economic costs upwards of \$100 billion and disrupt the stable spectrum environment that has allowed these innovations to scale.

NextNav's petition would significantly disrupt federal incumbents operating in the band. The U.S. Department of Defense and U.S. Department of Homeland Security rely on the lower 900 MHz band for mission-critical uses, including radar and law enforcement operations. Public safety and law enforcement officials across the country also utilize this band for essential systems supporting emergency response and situational awareness.

Ensuring robust and resilient PNT is undeniably vital to the nation's security and economic interests. However, this cannot be achieved at the expense of the foundational and widely deployed technologies that currently depend on the 900 MHz band. The current configuration of the 900 MHz band has enabled a thriving, market-driven innovation ecosystem, supporting billions of dollars in investment and a wide array of technologies that Americans rely on every day. We urge the U.S. government to reject NextNav's petition for rulemaking and instead support a technology-neutral path forward that preserves this proven innovation environment while allowing new PNT solutions to emerge and compete.

Sincerely,

Jason Oxman
President & CEO
Information Technology Industry Council (ITI)

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RAIN <> NextNav Interference Analysis

Study for RAIN Alliance Inc.

Issue 1.0



January 2026

RAIN <> NextNav Interference Analysis

Technical Report

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1 Introduction

This report analyzes *mutual* interference between authorized Part 15 RAIN RFID devices and NextNav's proposed 5G devices in the Lower 900 MHz Band (902-928 MHz), evaluating conditions under which significant interference may arise in either direction. The report ultimately concludes that, under real-world deployment conditions, there are severe interference scenarios associated with NextNav's proposal.

In April 2024,¹ NextNav petitioned the FCC to change rules for their Part 90 M-LMS licenses to use the Lower 900 MHz Band to operate mobile phone (e.g. 5G) services, and with this rule change, NextNav intends to monetize their licenses by providing 5G wireless voice/data services.

The RAIN Alliance firmly asserts that users of authorized Part 15 RAIN RFID, compliant with the current structure and rules of the Lower 900 MHz Band, will be adversely affected by NextNav's Petition and asked LS telcom (Radiosoft in the USA) to investigate and analyze the potential for *mutual* interference. NextNav's 'comprehensive' analysis² was limited to one-way interference into authorized Part 15 devices, but this report additionally includes interference into NextNav, since the two services are highly likely to mutually interfere.

NextNav requests the removal of protections for authorized Part 15 devices³ required by the Part 90 M-LMS licenses currently held by NextNav. The Part 90 Rules for NextNav licenses have clear language protecting authorized Part 15 devices. Given that a large population of authorized Part 15⁴ devices currently operate in the 902-928 MHz ISM band, this report thus considers mutual interference.

In related activity, CEPT PT1⁵ (Project Team 1), the group responsible for European mobile telecommunications (IMT) recently finished a report on the potential removal of potential sharers of their 5G and 6G mobile networks before leasing the new Upper 6 GHz band. The IMT community argued that

¹ See NextNav, Inc., Petition for Rulemaking, WT Docket No. 24-240 (filed Apr. 16, 2024), <https://www.fcc.gov/ecfs/search/search-filings/filing/10416238018537> ("NextNav Petition"); Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking, Public Notice, DA 24-776, WT Docket No. 24-240 (rel. Aug. 6, 2024).

² John Kim et al., *5G NR and Unlicensed Part 15 Technologies in the Lower 900 MHz Band*, NextNav Inc. (Feb. 27, 2025), attached to Letter from Renee Gregory, NextNav Inc., to Marlene H. Dortch, Secretary, FCC, WT Docket No. 24-240 (Feb. 27, 2025), <https://www.fcc.gov/ecfs/search/search-filings/filing/102280525327052> ("NextNav Study").

³ See Letter from NextNav to FCC, WT Docket No. 24-240, at A-4, A-6 and A-11 (June 7, 2024), <https://www.fcc.gov/ecfs/document/10607137757430/1> (removing, among other provisions, 47 C.F.R. §§ 90.353(d) and 90.361, which condition EA multilateration LMS licenses on the licensee's ability to demonstrate through actual field tests that their systems do not cause unacceptable interference to Part 15 devices and permit Part 15 operation without the requirement to protect M-LMS operations).

⁴ Nokia, Contribution to CEPT ECC PT1, Doc. PT1(24)172 (2024), <https://cept.org/ecc/groups/ecc/ecc-pt1/client/meeting-documents/file-history?fid=84757> (Nokia asserting that 160 MHz Wi-Fi use would adversely affect co-channel IMT. They use the term MFCN (Mobile & Fixed Communications Networks), because in Europe the mobile industry has reached saturation and is attempting to open a FWA (Fixed Wireless Access) market in the Upper 6 GHz.).

⁵ European Conference of Postal and Telecommunications Administrations, Electronic Communications Committee Project Team 1, <https://cept.org/ecc/groups/ecc/ecc-pt1/client/introduction>.

mobile phone networks cannot function alongside low- or very low-power devices, similar to those authorized under Part 15.

The mobile operators contend that interference is intolerable, as these low power devices would jam the uplink into the base station. Connectivity is also at risk because this interference would effectively knock mobile users off the network. So, based on these claims, and given the large population and diverse deployment of authorized Part 15 devices in the Lower 900 MHz Band, operation of a reliable 5G system as explained by NextNav is not credible.

RAIN RFID often operates with high duty cycles at power levels far exceeding that of the low-power devices that were considered in Europe—sometimes twenty times higher in power than 5G Mobiles. Therefore, authorized Part 15 devices in the Lower 900 MHz Band can create high interference blocking levels when signals are present around 5G Mobiles as well as interference into the 5G base station uplink channel (and indeed, sometimes interference into more than one 5G base station).

Mobile phone networks are a highly evolved trunked radio system, where the control plane for the network is frequency channels in licensed spectrum. For the 5G services proposed by NextNav, the control plane would consist of Resource Blocks in the 10 MHz downlink located in the Lower 900 MHz Band. Thus, NextNav's proposed 10 MHz downlink should be treated as a control plane, and 5G networks were not designed to share the control plane with other systems. While regulatory impacts are beyond the scope of this technical analysis, the likelihood of uncontrolled severe interference from Part 15 devices into NextNav's proposed 5G system (NN5G) will lead to untenable regulatory issues for the FCC and users of Part 15 devices:

- FCC and NextNav will have to locate and identify sources of Part 15 interference into NN5G.
- FCC will have to adjudicate interference issues and, when necessary, enforce the termination of Part 15 devices.
- FCC and NextNav will need to manage legal objections to NextNav claims, measurements and findings being used to suggest interference.
- Many users of authorized Part 15 devices will have to terminate the operation of their devices, nullifying their benefits and investments in Part 15 devices, installations, and training. Certain RAIN RFID devices, such as those deployed at airports, in hospitals, in high-risk shipment tracking and as used by the U.S. military and others, cannot be safely turned off.
- Users procured and operated authorized Part 15 devices in the Lower 900 MHz Band for over three decades with protections codified in Part 90 M-LMS Rules; revoking these protections would devastate those investments.
- In many other instances, unresolved interference from Part 15 devices into NN5G will deprecate or eliminate NN5G services, including the PRS signals that form the basis of NextNav's proposed 'backup GPS' services.

1.1 RAIN RFID overview

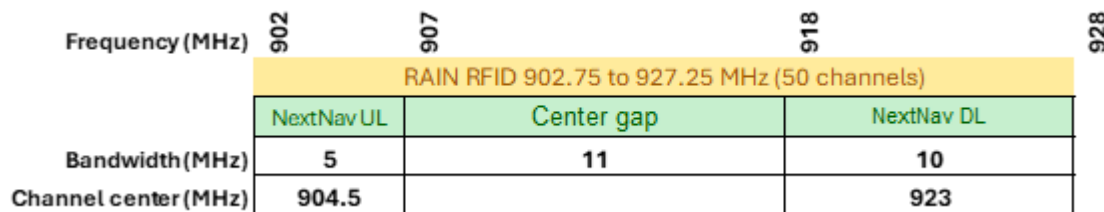
RAIN RFID devices are used in hospitals to locate medical devices and supplies, to track aviation parts, military ordnance and material, for road tolling, to manage building ingress/egress, manage inventory, track parcels, and assist in loss prevention, among many other everyday uses. Over the past 20 years, hundreds of billions of tags and hundreds of millions of reader devices have been deployed across the

U.S., typically operating indoors within a range of retail, industrial and enterprise environments. Thus, these devices can be densely populated within a large building/complex. In some instances, RFID readers are located at warehouse dock doors or retail entrances/exits, and in terms of RF propagation, these RFID readers can be considered operating outdoors.

RAIN RFID equipment consists of both handheld(s) and fixed RFID readers operating in fifty 500 kHz channels in the band between 902 and 928 MHz in the Lower 900 MHz Band. Operational range is short (10 m or less), and authorized Part 15 RFID readers produce energy to power the tag and allow the tag to identify itself. As permitted by Part 15.247, authorized Part 15 RAIN RFID operates up to 36 dBm (4 W e.i.r.p.).

The Lower 900 MHz Band is ideally suited for unlicensed RAIN RFID operation. Higher unlicensed frequency bands, such as 2.4 GHz, 5 GHz, and 6 GHz, provide enough bandwidth and are theoretically possible for RAIN RFID, but the propagation loss and attenuation loss at higher frequencies, along with the decreased efficiency of tag power-harvesting reduces operating range to unacceptable levels below 1 meter. Lower unlicensed frequency bands, such as 13 MHz, have less propagation loss, but insufficient bandwidth (only 14kHz at 13 MHz) would reduce identification rates to unacceptable levels.

Over the past decades, countries outside of the United States have followed the FCC's lead in the Lower 900 MHz Band by allocating frequencies for RAIN RFID. For example, Japan, China, and Europe (countries following CEPT/ETSI regulations) allocated frequencies in the Lower 900 MHz Band specifically for RAIN RFID.



Source: LS telcom

Figure 1: Typical RAIN band usage and the proposed NextNav plan.

In general, inventory management and parcel tracking applications use RAIN RFID readers that frequency hop over 25 MHz. In both applications, RAIN RFID systems are operating at maximum capacity to deliver 90% accuracy, so any reduction of bandwidth effectively reduces accuracy.

As an example of operating at maximum capacity, consider that a large retail store has over 100,000 different types of items and over 1.5 million individual items. Deployed RAIN RFID readers typically operate at inventory rates of 100-200 items per second, and conceptually, RAIN RFID readers would have enough capacity if all the inventory remained stationary. However, the value of inventory tracking is observing items being moved, and RAIN RFID readers must continuously inventory both stationary and moving items to determine which items have been moved; thus, RAIN RFID inventory management operates at maximum capacity.

Loss prevention is another RAIN RFID application that operates at maximum capacity. Conceptually, a RAIN RFID reader identifies 100-200 tags per second and would have plenty of capacity to alarm if a thief exited from a store with a single unpurchased item. However, an apparel store easily contains thousands of unpurchased items, and a theft prevention RAIN RFID reader at the exit often reads

hundreds of unpurchased items – some of these unpurchased items are on display near the exit and other unpurchased items appear as ‘stray’ reads due to RF reflections. In addition, a theft prevention RAIN RFID reader typically has multiple antenna beams in case a thief is physically blocking the unpurchased item from being read. And lastly, a theft prevention RAIN RFID reader prevents false alarms by re-reading an unpurchased item to ensure it is present at the exit. All of these additional complications – hundreds of unpurchased items, multiple antenna beams, and re-reading to prevent false alarms – mean that a theft prevention RAIN RFID system must operate at maximum capacity to properly alarm within a few hundred milliseconds if an unpurchased item exits the store.

The demands of RAIN RFID in loss prevention applications are similar to applications for loading parcels in delivery vehicles. Delivery vehicles are loaded with five hundred or more parcels, each parcel with a RAIN RFID tag, and a RAIN RFID reader identifies 100-200 tagged parcels per second. To prevent misloading of parcels onto a vehicle, a RAIN RFID reader must quickly identify all parcels – not just misloaded parcels – to promptly alert that a parcel entering the delivery vehicle should not be loaded.

1.2 NextNav System

The 5G 3GPP standard, 5G mobile phones, and 5G base stations do not specify nor support the 902-907 MHz uplink and the 918-928 MHz downlink band as proposed in the “NextNav 5G” system. For example, 5G mobile phones from Apple do not support the “NextNav 5G” band, and Apple has stated a preference for “...solutions that can use existing spectrum resources—including existing band plans...”,⁶ which indicates Apple’s aversion to using a new 5G band as proposed by NextNav.

Lacking a 5G standard as proposed by NextNav, LS telcom reviewed the parameters of the NextNav system submitted to the FCC. These parameters alone were insufficient to accurately model the effect of NextNav 5G (NN5G) on RAIN RFID and RAIN RFID on NN5G. However, we have made some conservative assumptions based on existing Low Band 5G deployments. Our approach is not to over-exaggerate, but to highlight potential interference cases that demonstrate the impact and risks for both sides.

Despite the absence of 5G equipment or a 5G standard as proposed by NextNav, we assume that NextNav will be providing a coverage scheme similar to existing 5G Low Band deployments: using wide-area low-capacity, with an emphasis on coverage.

5G user equipment (UE) also poses a clear interference risk to RAIN RFID systems, especially devices operating at Power Class 1 (PC1⁷), which could be transmitting at 31 dBm (1.25 W). Conventional 5G mobile phones operate at a maximum of 23 dBm (200 mW) but could still present a considerable interference radius to co-channel devices.

⁶ See Comments of Apple Inc., WT Docket No. 25-110, at 10 (filed Apr. 28, 2025), <https://www.fcc.gov/ecfs/search/search-filings/filing/1042813126394>.

⁷ https://www.etsi.org/deliver/etsi_ts/138100_138199/13810101/17.08.00_60/ts_13810101v170800p.pdf

Table 1: 5G Mobile power classes [extracted from TS1381011 Table 6.2.1-1: UE Power Class]

Power Class	Nominal maximum output power	Tolerance
1	+31 dBm	+2 dB / -3 dB
2	+26 dBm	+2 dB / -3 dB
3	+23 dBm	+2 dB / -2 dB

Note: Power Class 1 is not targeted for the smartphone form factor and is intended for Public Safety use in Band n14 only. (UL: 788 - 798 MHz / DL: 758 - 768 MHz)

2 Wide area statistical analysis – Scenarios 7 and 8

We undertook a wide area (Macrocell) statistical interference analysis using the industry recognized SEAMCAT⁸ Monte Carlo analysis tool to identify potential areas of conflict between RAIN RFID and NextNav's 5G. The primary concern identified was how RAIN RFID would affect the NextNav uplink consisting of NextNav 5G Base Station receivers located on tower sites, or Urban Macro sites, with high gain antennas. Conversely, RAIN RFID in the 5G Base Station downlink channel show results that are skewed by the random placement of devices by SEAMCAT over a wide Macrocell area, depending on several factors, and this is demonstrated clearly using localized area analysis in Section 3.

Wide area statistical analysis makes assumptions that do not reflect real life clustering of usage, so the wide area model diffuses the results with a broad-brush. This resulted in data that may mislead the reader into believing there is a low chance of RAIN RFID devices interfering with the downlink as even at average RFID density of 65 per square kilometer, it shows little statistical chance that it would be randomly located close enough to a 5G Mobile. This wide area approach is disjointed from the real world when other specific factors such as clustering (shops and other workplaces) are considered, which is likely to result in significant harm to the ability of 5G Mobiles in the vicinity to maintain communications with the network. Furthermore, the RAIN Alliance confirmed that localized area situations are far more likely within specific locations such as large retail stores, shopping malls, and industrial areas.

These scenarios study the potential for interference from RAIN to the NextNav 5G (NN5G) uplink and downlink paths, and were assessed using SEAMCAT, which is commonly used to evaluate the effect of co-channel or adjacent-channel interference between different networks at a regulatory and spectrum management level. SEAMCAT is most effective when modeling scenarios that are broadly representative of real-world conditions; it is less suited to analyzing localized deployments where device clustering creates interference patterns that statistical averaging obscures. Nonetheless, it reliably identifies the primary interference mechanisms and problem areas.

In this case, it was used to analyze broad interference scenarios to confirm engineering expectations, rather than probe the unknown. 5G is not designed to cohabit with other systems and has few mechanisms to cope with co-channel interference from unmanaged sources. Therefore, powerful,

⁸ European Communications Office, SEAMCAT: Spectrum Engineering Advanced Monte Carlo Analysis Tool, <https://www.cept.org/eco/eco-tools-and-services/seamcat-spectrum-engineering-advanced-monte-carlo-analysis-tool>.

almost continuous transmissions in the 5G uplink band are likely to be quite disruptive to the operation of the site over its entire coverage area, and this proved to be the case in the analyses.

The SEAMCAT scenario used a deployment of authorized Part 15 RAIN RFID readers with a density of 5 readers per square km, approximating the known deployment numbers and placing it on territory classified as 'urban.'

Approximately 5% of the USA is considered 'urban,' and this is where RFIDs are likely to be found in density, although they would be found anywhere where there are stores or industrial areas.

- USA surface area of approximately 3,532,000 square miles;
- Of that area, very approximately (depending on the definition) 176,600 square miles is considered urban;
- If 1 sq mile = 2.59 km²; then
- A population of 10 million RAIN RFID readers results in a count of 5.5 per km², or approximately 432 per base station because a 5 km radius cell has a coverage area of 78.5 km² (2pr2 = 25p). SEAMCAT rounds up to 6 devices per km² and extends the population of RFIDs out to 10 km to approximate a consistent result although the further away the RFID is from the base station, the less impact it has on direct RFID to 5G Mobile or 5G Base Station uplink. Considering the difference in power of a RAIN RFID reader versus a 5G Mobile, that distance could have been considerably larger, but would have skewed the results for direct RAIN RFID reader to 5G Mobile studies.
- The result of the analysis is given in the table below. The first result (Scenario 7) gives a predictably high data rate loss figure, approximating a system reliability of about 83.7%, and this result is purely taking into account the effect of RAIN RFID, not the design target of perhaps 95% (5% data rate loss). Outdoor RAIN RFID would degrade that to 78.7% reliability, and this is taking into account that the simulation assumed 75% of the devices were indoors and behind an additional 20% path attenuation. Remove that and the result is a system reliability of 59.6%, assuming a starting point of 95%, and this is without considering all the non-RAIN Part 15 devices and other authorized users of the band.
- Having a dense population of high duty cycle transmitters in the uplink channel running at 25x higher power than 5G Mobiles is an extremely aggressive interference environment and one that any system designer would wish to avoid at all costs.

Table 2: RAIN RFID vs NN5G: 75% indoor/25% outdoor RAIN and 100% outdoor RAIN

Scenario Number	Wide-area Scenario	RAIN Frequency range (MHz)		5G Center (MHz)	SEAMCAT data rate loss for NN5G with indoor/outdoor RAIN	SEAMCAT data rate loss for NN5G with outdoor RAIN
7	RAIN vs NN5G UL	902.75	927.25	904.5	16.3%	35.4%
8	RAIN vs NN5G DL	902.75	927.25	923	0.04%	0.056%

Several other wide area scenarios were considered, and none approached the value of Scenario 7. Most of the other scenarios were unlikely, experimental in nature, and served to validate the initial engineering assumptions so were not included here, but all gave very low possibilities of interference due to the randomized nature of the way SEAMCAT works. If a RAIN RFID device and a 5G Mobile were in the general vicinity of each other, then the possibility of (isolation) mutual interference was very high, but if the possibility of them being proximate was very low, due to the Monte Carlo effect, then the interference potential is shown as very low. However, if a number of devices are placed in a small geographical area near a 5G Base Station, interference potential skyrockets. This is considered in the specific scenarios described in Section 3.

SEAMCAT uses a vast number of input parameters, and whilst 5G defaults were used in most cases, some customization was included, such as the channels in use, as they are not on any 3GPP channel plan for 5G equipment, plus the RAIN RFIDs, which needed to be included as there was no predefined parameter set. It was quickly discovered that, whilst parameters could be varied, sometimes causing significant changes in the results, the overall system reliability proportions remained similar: the vulnerable path is always RAIN in the NextNav 5G Uplink band (Scenario 7). That has the effect of causing significant interference to the proposed NextNav 5G network, whereas everything else is shown, when using this randomized method, as relatively insignificant.

Interference to the uplink is likely to happen no matter what situation the 5G Mobiles were in as the interferer is likely to be constant and there is a non-zero chance it was also in band as far as the 5G Base Station was concerned, with 10 of the 50 channels in the uplink band (affecting 5G Base Station receive) and another 20 in the downlink band affecting 5G Mobile receive when proximate.

It should be noted that the statistical analysis addressed a single 3-sector base station and used a conventional static '60-degree' panel antenna radiation pattern. Active antennas are unlikely to be utilized in Low Band for efficiency and size reasons. The antenna pattern includes realistic sidelobe radiation in directions other than boresight, but sidelobes in such antennas are deeply suppressed and any resource blocks in use in one sector will most likely not be used in another on the same site, hence the usual planned maximum capacity in the busy hour of about 30% per sector.

Whilst planning for a maximum of 30% capacity sounds inefficient, NextNav proposes a single channel network, so the only way that all the sites can access bandwidth is by sharing, and the way to do this is to share out the available resource blocks across the estate, so in one geographic area, at any one time, a site using a resource block won't interfere with or be interfered by another site. This is quite normal, the infrastructure supports this facility, and most mobile operators will take this approach. NextNav has quoted 20% capacity per sector, which may appear acceptable in a Low Band network where inter-cell interference travels a lot further than strictly desirable, however, typical operation of single channel network systems occurs on controlled and purchased licensed spectrum, not within a crowded Part 15-Authorized band.

Resource block sharing is managed by the network, based mainly on the required capacity of the network users, so capacity moves around depending on where it's needed. This is an efficient way of managing a limited resource but also means that no one site or sector ever reaches the maximum capacity, so the maximum e.i.r.p is not achieved, either. It should be understood that total e.i.r.p is not as important as the power in a single resource block, as that is the link budget metric that governs the site's service area (coverage). Adding bandwidth requires an increase in e.i.r.p. but this does not mean an increase in service area unless the power in a resource block is increased. The NextNav quoted 66 dBm in a 10 MHz channel would be divided by 55 Resource Blocks (RB) of which, conventionally, only 51 would be

utilized⁹, which is 72.4 Watts per RB, meaning the actual maximum e.i.r.p. of 66dBm (4kW) is reduced to 3690 W, an inconsequential reduction. It should be noted that (4 kW is 1000 times the power of a 4 W Part 15 RAIN RFID reader and 20000 times the power of a 0.2 W 5G Mobile). Which figure, power in an RB, or total e.i.r.p. is considered when assessing interference or compatibility depends on whether the calculation is frequency-specific or not.

A resource block is transmitted and received independent of any other resource block. Think of it as being a narrowband communications channel, one of many on the site. So, it is not correct to assume that the e.i.r.p. minus Free Space loss, down to a minimum receive level above noise (say) will give you the maximum range of the site. It's a lot less than that, although a 66 dBm site on Low Band will return a usable outdoor coverage out to 10-15 km in rural areas, however a prudent network designer would have the 5G Mobiles hand over to a closer site before then as the uplink path is the limiting factor, even using diversity MIMO on receive (the site may use MIMO on transmit, but there it's using spatial multiplexing to increase data capacity, not diversity).

The e.i.r.p of one resource block, minus path loss, to a receive power level that gives a good data rate but maintains a good C/I with other sites using that resource block simultaneously, is the metric. So, there is almost never an 'edge of cell' situation. The planner would design the network to give, as much as can be managed with the resources available, a consistent user experience across the network area.

Essentially, an edge-of-cell situation only happens where the network designer is no longer interested in maintaining a consistent service. In that situation, 5G Mobiles would either roam to another network or band or be left to go out of service.

The simulation does not model this shared network but assumes simply that the 5G Base Station being interfered with is using the entire 5 MHz receive channel, but this works because of the interference-limited planning model, because the interference is continuous and comes from devices located across the cell and therefore if they're not interfering with the victim cell, they will interfere with the same resource blocks being used in adjacent cells. The path differs, but over many thousand iterations, it makes little difference. Also, this process is used merely to identify the problem mechanisms and provide some measure of the scale of the potential problem. The numbers don't matter – it's the proportion that matters.

In this case, the NN5G Uplink is *highly* vulnerable to significant interference and whilst there may not be much customer/positioning data traffic being passed in the uplink, without an uplink there is no closed loop mobile device control, and the network ceases to function.

3 Localized area scenario analysis

Whilst statistical analysis is good for identifying areas where coordination or mitigation is needed, it is clear that statistical analysis does not provide an unobstructed view. Real world cases and factual examples mirror how the technology is deployed. RAIN RFID systems by nature are located in clusters, in populated areas, in areas where cellular communications are prevalent. Therefore, real world situations demonstrate far more disruption than statistical analysis predicts.

⁹ In 10MHz, using 660x15kHz subcarriers, 55 Resource Blocks are available, but conventionally, the upper and lower 2 are suppressed to avoid adjacent channel interference (Guard Blocks). This means only 51 RBs are available for use.

Table 3: Traffic light table of interference severity based on SEAMCAT and real-world scenarios

#	Scenario	RAIN	NextNav 5G	Overall Effect
0	NN5G UL vs RAIN RFID Indoors	Localized interference	Widespread disruption if RAIN RFID is proximal to 5G BS	NextNav 5G most seriously affected
1	NN5G UL vs RAIN RFID Outdoors	Localized interference	Widespread disruption. 20dB worse than Scenario 0	NextNav 5G unable to operate
2	NN5G DL vs RAIN RFID Outdoors	NN5G DL jams RFID operation	Localized loss of service	Depends very much on proximity
3	NN5G DL vs RAIN RFID handheld indoors	NN5G DL degrades RFID operation	Localized loss of service	As in 2, but building loss is an advantage
4	NN5G UL vs RAIN RFID handheld indoors	Likely data loss due clash or wrong tag status due power scavenging	Small chance of occasional data loss due noise spikes on Uplink	Depends on proximity and 5G Mobile activity factor. RAIN would be a potential noise source to NextNav 5G
5	RAIN RFID vs NN5G UL	Localized interference	Widespread disruption if RAIN proximal to BS	NextNav 5G most seriously affected
6	RAIN RFID vs NN5G DL	Localized interference	Localized interference causing loss of service to 5G Mobile	NextNav 5G most seriously affected
7	RAIN RFID vs NN5G UL	Statistically LOW	Statistically HIGH	NextNav 5G unable to operate
8	RAIN RFID vs NN5G DL	Statistically LOW	Statistically LOW except in localized hotspots	Depends very much on proximity

RAIN Alliance offered the following scenarios, which we ranked by interference probability to RAIN RFID, NextNav 5G and likelihood. The premise was that, unlike the initial statistical analysis, which indicated a much higher likelihood of RAIN RFIDs interfering with the proposed NextNav 5G network's uplink reception, that there was a potential for the interference to go the other way: mutual interference, when the two systems were in close proximity, such as an existing cell tower on or near an industrial or retail park, of which there are numerous examples, and these are mostly legacy Low Band coverage grid sites of the type NextNav is likely to wish to use.

General notes regarding 5G Mobiles.

They will not transmit randomly. They will not transmit unless commanded to by a base station, i.e. random access is in specific random access uplink timeslot, which implies that the 5G Mobile has successfully decoded the base station's control plane and identified a random-access timeslot to send an Aloha on. Once 'in service', the base station controls transmissions thereafter. No assignment of a timeslot = no transmit, i.e. out of service. No acquisition of a control channel by the 5G Mobile = no service, i.e. no transmission.

This means that if RAIN RFID devices block the downlink, then 5G Mobiles in the vicinity cannot transmit. Considering the higher e.i.r.p. of RAIN RFID devices, (4 W vs. 0.2 W) they can also block the uplink even if located some distance from the site, in which case the base station may be unable to receive random access packets and all the 5G Mobiles on the site will go out of service. Interference to the uplink is more serious to a base station than local interference to the downlink. The interference contour of a RAIN RFID device with respect to a base station on a tower is non-trivial. If the site covers a retail or industrial zone, then the chances are that there will be several RAIN RFID readers operating in proximity, and this could represent levels of interference to the site far beyond design parameters (assuming a design 5% bitrate loss¹⁰, although this QOS metric depends on the application, 5% is considered normal (95% reliability), higher bitrate loss values quickly result in noticeably lower packet throughput due to retries¹¹). The statistical analysis returned numbers around 16% for the NN5G uplink, and this will be more than the design data rate loss. Resource block occupancy and antenna discrimination might mitigate this number, but overall, there will be an effect, notwithstanding the potential for a single reader to affect several sectors on adjacent sites.

¹⁰ European Communications Office, SEAMCAT Handbook § 12.2 (Ed. 4, Feb. 2025), <https://ecowiki.atlassian.net/wiki/spaces/SH/pages/492984/12.2+Overview+of+output+results> (For victim OFDMA systems, the interference criterion is the bitrate loss, i.e. the percentage of bitrate lost compared to a non-interfered victim network.).

¹¹ See 5G Quality of Service, DEVOPEDIA (Apr. 8, 2021), <https://devopedia.org/5g-quality-of-service>; Mahendra Adhikari & Daya Sagar Baral, *Interference Analysis of 5G in Coexistence Scenario with Short Range Devices (SRD)*, in PROC. 10TH IOE GRADUATE CONF. 1277 (2021), <http://conference.ioe.edu.np/ioegc10/papers/ioegc-10-162-10212.pdf> (essentially, 95% probability of service, i.e., 5% loss of data.).

Table 4: Overview of the scenarios assessed

#	Source		Victim		Analysis region		RAIN deployment
	Service	Device	Svc.	Dev.	Area	Category; use case	Number of readers; (and deployment area)
0	NN5G	5G Mobile UL qty 45	RAIN	RDR	2250m2	Retail apparel; Inventory management	112 fixed ceiling mount readers; 22,500ft2 (2250m2)
1		5G Mobile UL qty 20			1000m2	Retail apparel; Loss prevention	5 fixed readers for exit/entry gates; 10,000ft2 (1000m2)
2		BS DL qty 1			Local area (<1 km ²)		
3		BS DL qty 1			15,000m2	General retail; inventory management	5 handheld readers; 150,000ft2 (15,000m2)
4		5G Mobile UL qty 300					
5	RAIN	RDR	NN5G	BS UL	800m (0.5mi) to hub	Small logistics hub; package tracking pallet tracking	25 dock door readers 80 vehicle readers 20 conveyor readers; 75,000ft2 (7,500m2)
6				5G Mobile DL	Local area (<1 km ²) around hub		
7				BS UL	Wide area (5 km radius)	Generic	10million fixed readers over US, or 100million mobile readers (1% duty cycle) over USA
8				5G Mobile DL			

- Unless specified otherwise, all RAIN readers operate at 100% duty cycle with 36 dBm e.i.r.p. The main interference mode is blocking.
- There is an interaction between RAIN devices affecting the 5G operation and the 5G network and 5G Mobiles affecting RAIN devices, and these effects vary by distance and interference power in a RAIN device channel

3.1 Scenario 0

3.1.1 Introduction

In this scenario, the likelihood of interference from local NextNav 5G emissions to RAIN RFID devices used in inventory management was investigated.

The scenario assumed a retail outlet, utilizing a network of 112 ceiling-mounted readers, with RFID tags on each item of clothing to not only manage inventory but indicate the approximate location of each item.

Customers have a habit of not placing items back on the racks where they found them, necessitating regular and costly manual search of the rails for misplaced, hidden or missing items. RAIN RFID saves the business a considerable amount of money, because counting stock is automated, and misplaced stock can be returned to the correct rails.

The RAIN RFID industry estimates that an inventory management accuracy of 95% using RAIN RFID drops to 65% without RAIN RFID.

3.1.2 Interference Vectors

The investigation assessed the possibility that 5G Mobiles in use in the store would interfere with the readers, however, there are multiple interference vectors at play in this scenario, which means that:

- RAIN RFID in the store operating on the NextNav 5G downlink may knock local 5G Mobiles out of service.
- RFID tags may harvest enough energy from the 5G Mobiles or even the 5G base station, to interfere with the tag reading process.
- There is an interaction between RAIN devices affecting the 5G operation and the 5G network and 5G Mobiles affecting RAIN devices, and these effects vary by distance and interference power in a RAIN device channel.

Note: This kind of venue would also have readers on the exits to manage shoplifting.
See Scenarios 1 & 2.

3.1.3 Analysis

The scenario assumes 112 RAIN RFID operational in the store. In addition, 45 customers are using 5G Mobiles operating on the NextNav system, although not simultaneously because there are only 23 available Resource Blocks, so at any time, perhaps a maximum of 23 5G Mobiles can be transmitting, and if any are consuming more than one 5G Resource Block, the number will be smaller. For this reason, the approach would be to model the interaction between one RAIN RFID device, one 5G Mobile on three 5G Resource Blocks (absolute worst-case would be three 5G Mobiles running 23 dBm on adjacent 5G Resource Blocks, but this is less likely), one 5G Base Station located in the vicinity, but outdoors (line of sight).

The analysis of NN vs RAIN was not undertaken using SEAMCAT as the area of operation of the scenarios was small and specific, i.e. a retail floor, so this could be approached with interference radii and some system logic.

RAIN RFID devices frequency hop, with a dwell time of no more than 0.4 seconds (400ms) before moving off. This means that of the 112 readers, the chances are that every channel in the band will have a constantly changing population of readers on it.

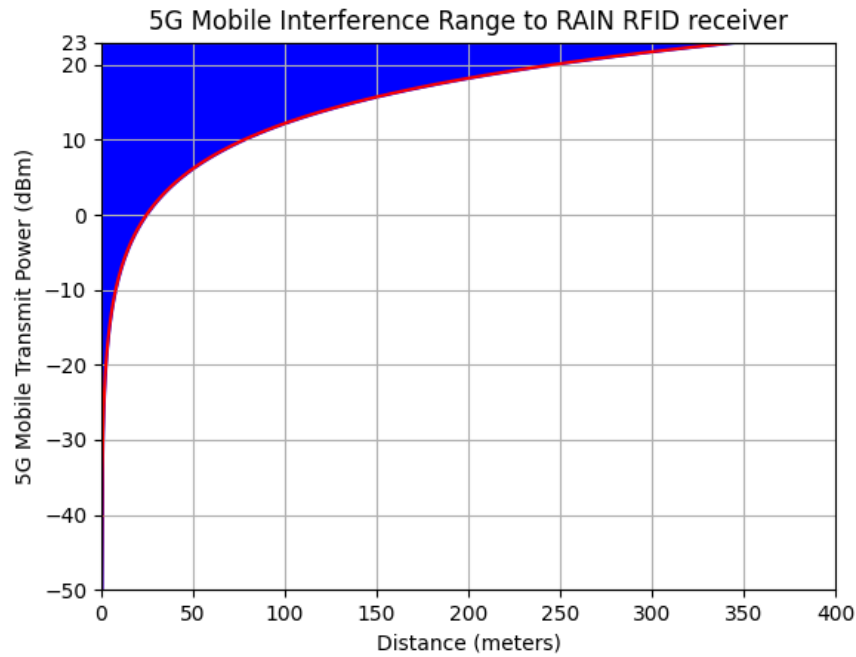
A 5G Mobile would have to cope with local noise sources changing every downlink 20 frames, making communications with the 5G Base Station discontinuous at best. However, it may not entirely lose the base station and could have the opportunity to transmit and that will inevitably affect one or more readers. It should be noted that the uplink would also be similarly affected, potentially rendering the site unusable.

A 5G Mobile has, if you assume the full 23 dBm within a single RFID channel (3x5G resource blocks), a maximum interference radius of 370 m. We assume that the 20 dB building ingress loss is the same for egress, so the 23 dBm becomes 3 dBm outdoors, which is not a lot, so the 5G Mobile will most likely be commanded to run close to full power due to the obstructed path to the 5G Base Station, not taking into account any interference (noise) in the uplink band.

The main issue will be the mobile exceeding -60 dBm at the RAIN receiver, and how this could happen.

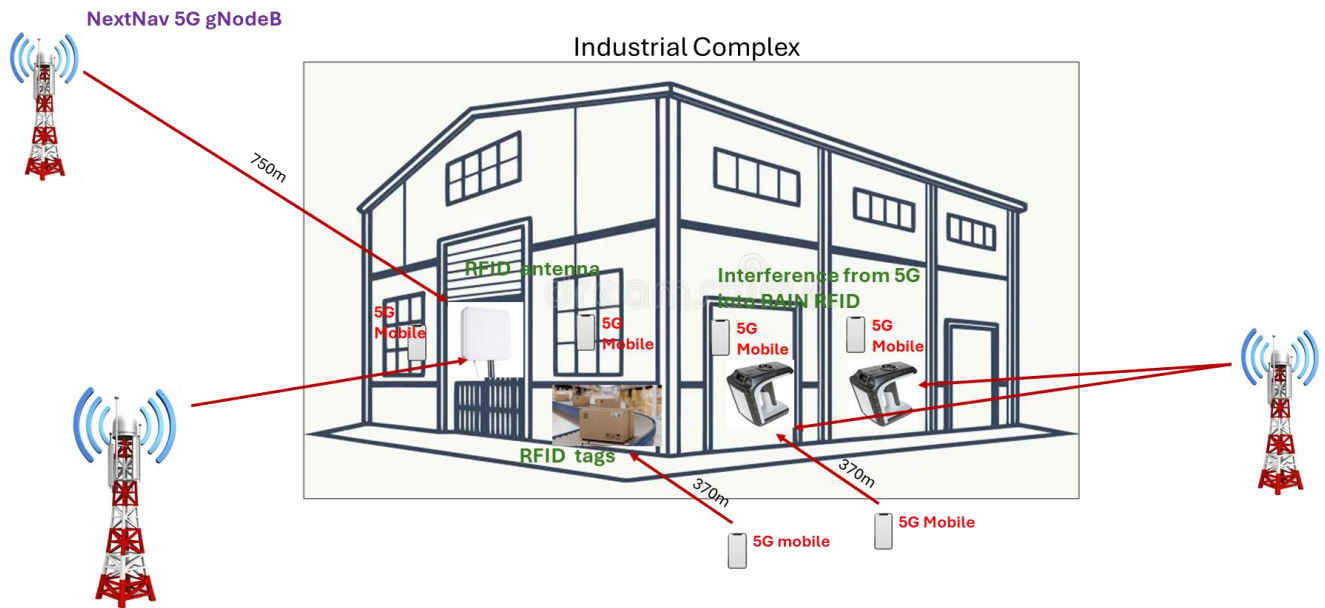
The distance from the 5G Mobile to cause sufficient interference to the RAIN RFID reader will be a function of transmit power of the mobile - which can vary depending on the distance to the base station and the number of resource blocks used - and the minimum power required to interfere with the receiver. As a first approximation, using the Friis equation, and assuming a 0 dB gain antenna for the 5G Mobile and a 9 dB gain antenna for the RAIN RFID Reader and operating at nominally 915 MHz, we can calculate the receive power at the RAIN RFID receiver. These assumptions can be presented in a graphical plot. See Figure 2. The shaded blue area in the graph below shows the distance/5G Mobile transmit power that would be sufficient to disrupt the RAIN RFID reception of tag signals.

Most likely, this will happen when the 5G Mobile is distant from the 5G Base Station, but also it is indoors, so the path loss will be 20 dB higher than normal, so the distance to the 5G Base Station will be less.



RAIN Alliance

Figure 2 5G Mobile Interference Range to RAIN RFID receiver



Source: LS telcom

Figure 3 Interference and pathloss NextNav to/from RFID

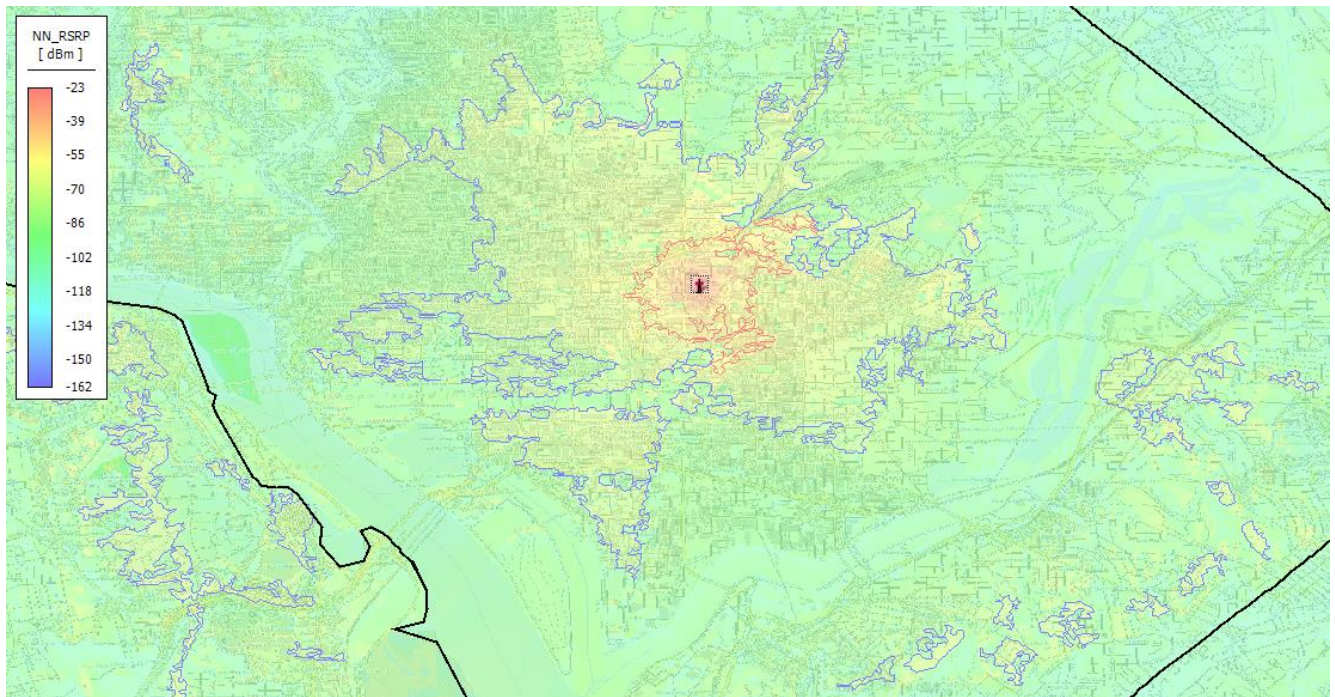
Table 5: Tabular illustration of Figure 3

Interferer	Interference vector
5G Mobile	370m -> RAIN (-60 dBm)
5G Base Station	750m - 20 dB wall -> RAIN
RAIN	1000m - 20 dB wall - 16 dB ant -> 5G Base Station

A 66 dBm e.i.r.p. 5G Base Station will be running 51x 5G Resource Blocks max (assuming 15 kHz subcarriers, which is more conventional in Low Band than 30 kHz subcarriers), each is 66 dBm divided by the number of available Resource Blocks, in this case 55, although only 51 would be used (49 dBm or 72W per 5G Resource Block, approximately, because of the four not utilized.). This equates to roughly 7km of high-quality range outdoors, assuming no clutter or extreme terrain effects.

This indicates that there is scope to extend acceptable coverage out to the usual Low Band intercell range of 5-15 km. A typical scoping plot of RSRP (essentially the range of a single resource block) is shown below, centered on FCC HQ for familiarization reasons. The transmitter is represented as operating omnidirectionally but with a boresight gain of a conventional sector antenna. Conventionally, scoping plots do not include sectorization or antenna H-plane pattern, but the coverage to every pixel on the map assumes boresight gain. As the main reason for the plot is to illustrate the assumptions in the text for distances between devices, the detail design of the site is not particularly important.

It is important to understand that the larger the cell radius, the more RAIN RFID devices are in the service area, which not only increases the likelihood of interference to RAIN, but also uplink interference to the 5G Base Station. In the statistical analysis, we assumed a cell radius of 6km, and this may be conservative, but extending the study service radius increases the number of RAIN devices in the SEAMCAT analysis, the 5G Mobiles are progressively less able to gain high-quality links to the 5G Base Station becoming progressively more vulnerable to being interfered with, and this quickly becomes unrealistic except in areas where there are likely to be RAIN devices over a wide area in a generally uniform distribution. 6km is, therefore, a balanced estimate with no calculated advantage to either party.



LS telcom

Figure 4: RSRP Basic coverage of notional 30m AGL 5G Base Station in NextNav band. Omnidirectional (antenna 30m AGL, no sectorization applied) showing -60 and -40 dBm contours (outdoor and indoor -60 dBm assuming 20 dB ingress loss). Black lines are State lines.

A RAIN device (36 dBm) exceeds -60 dBm with NO ANTENNA GAIN at 1500m. If nominal 20 dB wall attenuation and basic antenna gain at the 5G Base Station is included, the interference range is 1km. This means the RAIN RFID device affects the 5G Base Station well before the 5G Base Station affects the RAIN device.

Of the 112 RFID readers in the ceiling, if it is assumed that they are hopping across the band in a semi-random way, dwelling on a channel for 400ms (20x 5G frames) before moving to another. On average, we can assume just over two RFID devices per channel. This means that at any one time there will be 10 devices in the store transmitting across the NextNav uplink. As the devices are running more power, albeit directionally, than the 5G Mobiles, which will be compromised by inefficient antennas (the mobile industry assumes an implementation loss of around 6 dB), the fact that everything is indoors makes little difference as the base station could be local or distant, the relative signal levels from the devices involved would be the same. The only difference is that if the retail store was close to the base station, then the interference would affect reception of 5G Mobile uplink outside the store as well.

The 5G Mobiles in the store would fare little better. Again, if the base station was local, then there is a chance that in some areas the 5G Mobiles would be able to receive a downlink and remain in service, but the 20 RFID transmitters across the store that are operating co-channel with the downlink, with 9 dBi antennas pointing directly at the 5G Mobiles, will likely be significantly stronger. The result is the 5G Mobiles in the store will eventually go out of service if they cannot maintain a 6 dB C/I. (See Annex I)

For the RAIN devices, the chance of a 5G Mobile interfering is reduced, as the interference to the downlink is significant enough to keep them out of service and silent (they cannot proceed to transmit

unless they receive a control channel burst that indicates a random-access slot they can use, and even then, they will be unable to maintain the control channel (SSB) due to the interference.

The RAIN devices may suffer significant interference from the 5G base station, but assuming a 20 dB ingress loss¹², the boresight gain of the RFID antenna mainly pointing downwards and the e.i.r.p. involved, the base station would have to be very close, which means it would be compromised on the uplink by RAIN interference and most likely unable to maintain any service to 5G Mobiles that are not outside and in close proximity to it.

A 5G 'rogue device' (in this case a RAIN RFID) is 3GPP terminology for a signal source that is not authenticated and not scheduled and will look like unexpected uplink energy in specific resource blocks to the 5G base Station, which has no way of identifying the interferer beyond understanding which Resource Blocks are affected.

The 5G Base Station's uplink receiver performs continuous per-Resource Block energy measurement, so the RAIN RFID appears as uplink interference noise across up to three Resource Blocks:

- In Resource Blocks where no 5G Mobile should be transmitting
- Overlapping with the scheduled 5G Mobile's Resource Blocks
- To the 5G Base Station's PHY layer, it simply appears as random uncorrelated co-channel interference, which leads to:
 - Lower UL SINR
 - Lower MCS
 - More HARQ retransmissions
 - Capacity collapse
- Uplink may collapse for more distant 5G Mobiles as the 5G Base Station commands Mobiles to operate at higher power to overcome the noise.
- Reallocating Resource Blocks away from those with RAIN RFID interference only works when the interference is limited. If the band is occupied in 500 kHz bands of noise, the characteristics and level of which are altering every 400ms, then that is another problem altogether. The scheduler will be working hard to try to overcome the interference, and as the effect is unpredictable, retries will be common and cumulative. The 5G base station cannot control this interference.

3.1.4 Results

It is most likely that 5G Mobiles in the vicinity of the fixed RAIN RFID readers operating in the uplink band will be unable to receive the base station due to interference caused by those RAIN RFID readers operating in the downlink band, which are unaffected by the 5G Mobiles. If the 5G Base Station is close range to the store, then it has a higher probability to affect RAIN readers in the downlink band, but then the 5G Mobiles will be running much lower than maximum power and this means that RAIN RFID will be operating in the uplink band, jamming the 5G Base Station uplink, affecting the entire service area of the

¹² ITU-R, Recommendation P.2109-2, Prediction of Building Entry Loss (Aug. 2023), <https://www.itu.int/rec/R-REC-P.2109/en>.

5G Base Station. It is therefore a very bad situation for a NN5G Base Station to be operating near a facility running RAIN RFID.

3.2 Scenarios 1 and 2 Retail apparel – Loss prevention

The next two scenarios are considered together as, like in Scenario 0, there is a combined effect on both uplink and downlink bands.

3.2.1 Introduction

Scenarios 1&2 are similar to Scenario 0, although in this case the victim is loss prevention equipment installed near the store exit. The scenario investigates the potential for a tag on an item of clothing being smuggled out of the store is in close proximity to a NextNav 5G Mobile. Some concepts will be mentioned here, having been defined or explained in Scenario 0, and for brevity, will not be repeated in this section.

3.2.2 Interference Vectors

There are two potential interference paths:

- Inadvertent energization of the tag by the 5G Mobile, making it not respond appropriately to the reader; and
- Jamming of the reader by a co-channel emission from the 5G Mobile.

3.2.3 Analysis

As with Scenario 0, the RAIN RFID device in the uplink band will probably benefit from the level of interference caused to the 5G downlink within the store. It's a gamble for the NN5G user as it is by no means certain the 5G Mobile will be transmitting at the same instant as passing through the gate, and if that was the intention, then a normal LMR radio programmed for this band would certainly do the job with far less uncertainty, so the interference would almost certainly be unintentional.

However, if, for some reason, a 5G Mobile is still able to get service from a base station, then the interference contour towards a fixed RAIN RFID device is considerable. The 5G Mobile would, if co-channel with a RAIN RFID, be unaware of the RAIN device, but the 5G Base Station would be very much aware of it and would either:

- Move the 5G Mobile to other Resource Blocks that are not being interfered with; or
- Command the 5G Mobile to run full power to attempt to overcome the RAIN RFID interference.

With a 5G Mobile running the full 23 dBm in 1-3 5G Resource Blocks (all 5G Mobile power in the 500 kHz passband) the point where the signal drops below -60 dBm is 150m if assuming a 7 dB implementation loss, and 370m if the antenna is assumed to be efficient. With body position and other factors, the true range will be something between those two extents.

On a busy floor, there would be assumed to be 2 RFID devices per channel at any point in time, so this means 20 RFID interfered with, depending on the number of Resource Blocks in use, or number of 5G Mobiles in use. 5G Mobiles will not be reusing Resource Blocks, so no more than 24 phones can be in use

in any moment, but as a RAIN device dwells on a channel for 400ms, that's 20 frames in which multiple 5G Mobiles can transmit.

We are assuming a single 5G channel, shared over three sectors, with all the adjacent sites sharing the available 5G Resource Blocks. 30% of maximum capacity in the Busy 'hour' (not always an hour) is a planned upper figure, but NextNav has stated 20%, which is reasonable considering the network as a whole. However, worst-case is still three local 5G Mobiles operating full power on adjacent 5G Resource Blocks on one or more frames within an individual RAIN device passband. This will cause blocking, or at the very least, a loss of backscatter from the energized tags, which may then be missed.

This means that if it is on the same sales floor as a RAIN reader, if co-channel, it will interfere for the duration of transmission. Streaming video or even a simple phone call will disrupt the RFID receiver. The 5G Mobile will have no way of knowing that a RAIN device is on the channel as it cannot listen, the network has no mechanism for identifying that there is interference in the channel other than detecting noise-like issues. In mitigation, the presence of RAIN RFID devices in the uplink band could, with proximity, be fatal to the 5G Base Station's ability to operate, especially if they are running with a near 100% duty cycle. They would also be producing a noise level in the uplink above that the 5G Mobile would be able to overcome. If all the uplink band is occupied by RAIN RFID, then the situation for the 5G Mobiles in the vicinity would be grim and they would most likely already be out of service due to multiple NACKs from the Base Station. It should also be noted that the uplink interference will be relentless, and will have happened from the moment the site is first deployed, and will continue until the site is switched off.

3.2.4 Results

RAIN Mitigation: RAIN RFID operating in the uplink will adversely affect the service status of 5G Mobiles in the vicinity, and for a larger contour than the 5G Mobiles could affect the RAIN RFID devices co-channel with the 5G Base Station, depending on how close the 5G Base Station is, as if it is very close then the 5G Mobiles will be running lower power with a smaller interference radius. This means the 5G Base Station will be affected by uplink interference, and this would affect the entire sector, not just in the vicinity of the RAIN RFID. The 5G Base Station would not be able to discriminate or notch out the interference as it would be continuous, but constantly varying, and on every available Resource Block with a relatively high power density. A similar situation to Scenario 0 with a similar outcome.

3.3 Scenarios 3 and 4 – Handheld RAIN RFID readers

In these scenarios, the effect of NextNav signals on handheld RFID tag readers within a general retail environment is studied. This scenario is largely focused on indoor emissions.

3.3.1 Introduction

The use of RAIN RFID results in a 95% stock level accuracy as opposed to 65% if RFID is not used. It is expected that 5G Mobiles in the vicinity will affect RFID readings, resulting in missed tag responses that may not be visible to the operator.

3.3.2 Interference Vectors

- Local 5G Mobiles would block a RAIN RFID channel causing loss of backscatter responses; or
- Tags would scavenge energy off the 5G Mobile and not be in the correct session mode when queried by the reader.

3.3.3 Analysis

Path loss at 2m is approximately 36 dB. The signal level from the tag will be -30 dBm e.i.r.p and -66 dBm e.i.r.p at the RAIN RFID reader. A 5G Mobile only needs to be within 380m to overcome the return from the tag.

Tags that have scavenged power from the 5G Mobile and are not in a queryable state can be reset by an inventory command before reading, although this relies on the interference having ceased.

3.3.4 Results

It is entirely possible that a NN5G Mobile would be operating within 380m of a RAIN RFID reader in a retail environment, where the use of NN5G cannot be easily curtailed. It is therefore possible that NN5G can interfere with the read process of an RFID reader, and, if close enough, energize the tags and interfere with the read process *even if not specifically operating on the same channel as the RAIN RFID reader*.

3.4 Scenario 5 and 6 – Parcel Delivery Depot

This scenario considers the effect of a parcel delivery depot RAIN RFID deployment within the service area of a NextNav 5G Base Station. This assumes the 5G Base Station is within 800m of the installation, which is not unusual as earlier cell towers used in the Low Band grid were often located on such sites. Less local use is considered in Scenarios 8&9.

3.4.1 Introduction

The installation contains 25 dock door readers, 80 vehicle readers, 20 conveyor readers, 125 devices in all. We assume that the readers at the dock door transmit emissions outdoors as well as indoors and the vehicle readers are outdoors. These facilities are often operational 24 x 7 meaning there are no gaps for sharing.

3.4.2 Interference Vectors

The NN5G site is 800m distant. At Mid Band frequencies, that would be considered edge of cell, but in Low Band, it is well within the high-quality service area and as many of the deployed devices are outdoors (i.e. dock door readers and vehicle readers), so this would be considered a near worst-case as their e.i.r.p (36 dBm) is 13 dB above that of a standard mobile phone and they operate with a 100% duty cycle.

Additionally, the RAIN RFID devices in the downlink band would exceed -60dBm (and likely block service) to 5G Mobiles for nearly 1500m around the site.

3.4.3 Analysis

No extensive analysis is required besides a free space pathloss calculation which shows the impact of the 4 W e.i.r.p transmit power from the RAIN readers will have on the 5G mobile receiver (downlink). It will be completely blocked within a 1500 m radius (-60 dBm).

At this installation density, at this distance from the site (800m), and with all devices operating across many (most) of the available channels with a 400ms dwell time, we consider that no simulation is required: with a free space path loss of 90dB, and an antenna gain at the NN5G Base Station of approximately 16dBi, the resulting signal level of -37.5dBm would completely block the uplink and the NN5G base station would be unable to operate.

3.4.4 Results

The overall results of this scenario indicate that interference from RAIN readers into 5G mobiles would be significant (rendering them largely inoperable) given the concentration of RAIN devices operating continuously at the allowable maximum power. This scenario can be considered one of the worst-cases due to the extensive outdoor usage by these devices.

3.5 Scenarios 7 and 8 – population of RAIN RFID across a 5G Base Station service area

These were covered in the previous statistical analyses. See Section 2 for details. We present just the broad findings here.

3.5.1 Introduction

In an effort to illustrate the potential impact of general average levels of interference to 5G from a population of RAIN RFID (not including all the other Part 15 users in the band, which is another level of complexity and interference potential altogether).

It must be emphasized that the 16.3% data rate loss is almost entirely reliant on assuming that indoor RAIN RFID devices are being attenuated by 20 dB egress attenuation. This means that the adverse effect on the 5G Base Station is significantly lower than what it would be if there was no additional attenuation in play. In fact, without that 20 dB extra loss, the 5G Base Station would be completely swamped with a 35% data rate loss, *i.e.*, a reliability of 65%, and that's a randomized average. If there were a local hotspot of RAIN RFID activity, that may completely block the uplink.

3.5.2 Interference Vectors

Here, the issue is mainly that the RAIN RFID readers run significantly more power than the maximum power available to a 5G Mobile, will be distributed evenly across the 50 channels available to them, and move frequency every 0.4 seconds, which means that there is an almost constant presence of a high-powered interferer on every RAIN RFID channel across the service area of the 5G base station. Their location and channel used changes randomly every 400ms, causing levels of noise-like interference likely to critically damage the 5G Base Station's ability to operate.

3.5.3 Analysis

See Section 2.

3.5.4 Results

The results showed that the main interference vector between RAIN and 5G was to the uplink band, where the average interference could be significant enough to make the operation of an affected base station impossible. It should be noted that this scenario concentrated on average, statistical, values and assumed a random population of RAIN RFID devices across and beyond the 5G Base Station's service area. In reality there would be concentrations of RAIN RFID devices at various distances, perhaps affecting one sector more than another, although the concentrations would also be in areas where the 5G users would more likely be concentrated. Also, the RAIN RFID runs at power levels that equate to a far longer range to the 5G Base Station than was simulated.

It must be emphasized that the 16.3% data rate loss is almost entirely reliant on assuming that the 75% of indoor RAIN RFID devices are being attenuated by an egress attenuation quoted as 20 dB. In fact, within SEAMCAT it's a little more complicated than that, with a 50% probability of the device being in a thermally-efficient building (with far higher attenuation) or in a conventional building with around 16 dB attenuation. The average is about 20 dB.

This means that the adverse effect on the 5G Base Station is significantly lower than what it would be if there was no additional attenuation in play on 75% of the interferer population. In fact, without that '20 dB' extra loss, the 5G Base Station would be completely swamped by the resulting 35% data rate loss, *i.e.*, a reliability of 65%, and that's a randomized average. If there were a single local hotspot of RAIN activity, that would completely block the uplink and result in total failure of the cell.

Table 6:RAIN RFID vs NN5G (75% indoor/25% outdoor vs 100% outdoor)

Scenario Number	Wide-area Scenario	RAIN Frequency range (MHz)		5G Center (MHz)	SEAMCAT data rate loss for NN5G with indoor/outdoor RAIN	SEAMCAT data rate loss for NN5G with outdoor RAIN
7	RAIN vs NN5G UL	902.75	927.25	904.5	16.3%	35.4%
8	RAIN vs NN5G DL	902.75	927.25	923	0.04%	0.056%

4 Conclusions

Overall, our findings indicate that both RAIN RFID and NN 5G systems are disrupted based on sharing access to the 902-928 MHz band. The most significant interference arises in the localized scenarios (as

opposed to wider area simulations) when RAIN RFID devices and NN5G are closely located and concentrated. The most significant impact from these scenarios would be 100% loss of the NN5G service due to continuous blocking of the uplink traffic, such as link management operation, affecting the service status of all the 5G Mobiles in the affected sector.

Findings and Conclusions

We summarize our findings and conclusions below.

- We found from the analysis that, depending on the scenario, NextNav 5G devices will cause significant interference to RAIN RFID and vice versa, although the interference to NN5G borders on complete denial of service in some scenarios due to 100% blocking of the uplink channel.
- The Monte Carlo simulations cannot be viewed in isolation since they express data in generalized statistical averages. However, even Monte Carlo shows data rate losses impacting NN5G when RAIN RFID devices are randomly distributed in a wide area up to 10 km from the 5G Base Station. The only reliable method to determine the economic impact and disruptive impact is to assess real world examples, which we have provided herein. The real-world desktop analysis clearly shows that a small-to-medium industrial or retail RFID installation in the vicinity (within a few 100 meters) of a NN5G base station could completely jam the uplink and force the base station's 5G Mobiles out of service. Additionally, if the 5G Mobiles were close enough to RAIN RFID they would mutually interfere with each other until the 5G Mobile was unable to maintain a link to the 5G Base Station and would then go out of service.
- If NextNav operates a 5G system in the band, then simple random access mitigation techniques will not suffice. Changing the frequency range for NN5G operation to 902-907 MHz and 918-928 MHz does not solve the issue that NN5G will be blocked by Part 15 devices including RAIN RFID, as 5G Mobiles would not be able to receive BS signals, when within a RAIN system installation like for example an urban environment or shopping mall.
- The initial SEAMCAT results are statistical in nature and randomize the distribution of RAIN RFID 'interferers' without considering localized hotspots, which are likely to occur in the vicinity of any urban NN5G installation.
- The SEAMCAT simulations did not consider any other Part 15 device other than RAIN RFID. This leaves a considerable population of potential additional interference to NN5G out of the calculations, although RAIN RFID is more than enough to adversely affect NN5G operations on its own.
- A 5G base station is effectively a multi-channel trunked radio controller, utilizing resource blocks in the same way as physical channels, although with the added complexity of being able to assign multiple channels to a mobile to increase throughput. Historically, trunked radio systems have been assigned dedicated channels because they are unaware of sharers, and both cause and suffer interference from them. The question here is whether it is possible to convert a Part 15-compliant system into a 5G trunked controller in a busy and popular shared band without causing serious future regulatory and spectrum management issues. The sensible option would be to place a 5G system into a band suitable for 5G systems and not try to technology-swap an application from a compatible to an incompatible one in-band.

Annex I. Link management in the uplink in the face of interference

Mitigations by 5G Mobiles When Uplink Messages/Packets Aren't Being Received

When the 5G Base Station fails to decode uplink messages, several automatic mitigation mechanisms activate. These happen in a fixed sequence, as defined by 3GPP.

Step 1. HARQ Retransmissions

When UL *PUSCH* blocks fail:

- 5G Mobile receives **NACK**
- 5G Mobile retransmits the packet using incremental redundancy
- Up to max *HARQ* attempts (usually 4–6)

If *HARQ* fails, then the RLC layer steps in.

Step 2 RLC Layer Retransmissions (ARQ)

If MAC-level *HARQ* cannot recover the packet:

- RLC *AM* (Acknowledged Mode) retransmits
- Timers (*t-PollRetransmit*, *t-Reordering*, *t-StatusProhibit*) may expire
- More uplink load and delay accumulate

5G Mobile sees increasing delay and jitter.

Step 3 Uplink Power Control Compensation

To counter interference:

- 5G Base Station sends **TPC UP** commands
- 5G Mobile increases TX power
- 5G Mobile may hit P_{max} (max allowed power, e.g., 23 dBm)

Once at P_{max} , the 5G Mobile cannot compensate further and throughput collapses.

Step 4 Reduction in MCS (Modulation and Coding Scheme)

Scheduler uses CQI to adapt to poor SINR:

- 5G Mobile gets more robust, lower coding rate such as QPSK, which lowers throughput but improves reliability;
- 5G Mobile may receive more Resource Blocks to overcome the lower throughput (if available)

Step 5 Re-transmit or Re-schedule Resource Blocks

If the interference is frequency-localized, as in the case of a local RAIN RFID, then:

The 5G Mobile is moved to cleaner resource blocks if allowed, or possible, which is unlikely in a multi-reader environment.

Step 6 *RACH* Restart (Random Access)

If UL control channels fail completely then the 5G Mobile may have to go through a hunt process to re-establish a control channel on another site (not likely on a thin, single channel network):

- 5G Mobile may trigger RLF (Radio Link Failure)
- 5G Mobile performs RRC re-establishment or full RRC reattachment
- This resets MAC/RLC state and tries again

This occurs when PUCCH/PUSCH control is fundamentally lost, i.e. the 5G Mobile is 'out of service'.

Annex II. Mitigations available to the 5G Base Station

The 5G Base Station has a choice of actions available to it, such as:

2.1 Scheduler Interference Avoidance

- Move 5G Mobiles away from noisy Resource Blocks
(a bit difficult if all RBs are being interfered with, but otherwise a good strategy)
- Reallocate frequency/time resources (Wait for the interference to clear)
- Allocate more symbols for DMRS (Demodulation Reference Signals, basically, analyze the channel more deeply)

2.2 Boost UL Power for Affected 5G Mobiles

Using closed-loop power control:

- More *TPC UP* commands
(Command the 5G Mobile to increase power)
- Aim: increase desired *C* to offset *I*
(a problem if the '*I*' from a 4W eirp RAIN RFID is always much, much stronger than the available 200mW '*C*' from the 5G Mobile)

2.3 Trigger Interference Detection/Location

If noise rise persists:

- OAM (Operations, Administration, and Management) alarms are initiated
(This will happen soon after the site is switched on for the first time, probably within a few seconds, and persist until the site is switched off again.)

2.4 Handover Away from Interference

- 5G Mobile is steered to another cell/site where UL interference is lower.
(Unlikely in this scenario as the 5G Mobile is probably only in range of a single site and if the interference is in the uplink of one site, then it is unlikely that other local sites are unaffected, and given the standing population of RAIN RFID devices, other sites will have their own problems to overcome.)

Annex III. What Happens in Severe Interference Scenarios?

It is understood that in the worst cases the following actions take place:

- 5G Mobiles hit max transmit power
- HARQ retransmissions saturate
- Uplink control (SR, BSR, CSI reports) fail
- RLC timers expire
- RLF occurs
- 5G Mobile drops the connection
- 5G Mobile attempts RRC Re-establishment or performs a full attach (Comprehensive Hunt)

This is the classic “UL collapse” trunking failure mode.

Annex IV. 3GPP network specification regarding reconnect times

When a 5G Mobile loses its link (e.g. due to interference causing a radio-link failure — RLF), the reconnection process is governed by several timers and procedures defined in the 3GPP standards. The relevant documented values give a lower-bound / typical timescale, which you can use to build a chart for Monte Carlo or performance analysis.

Key timers, events and what they imply:

Event / Timer	What it means / does	Typical / default / normative value
T310 (RLM / RLF detection timer)	When 5G Mobile detects consecutive “out-of-sync” or poor signals and declares radio-link failure	TS 38.331 13 UE-TimersAndConstants Configurable to (milliseconds): {ms0, ms50, ms100, ms200, ms500, ms1000, ms2000}
Time to power-down uplink after RLF	Once RLF is declared, 5G Mobile should stop transmitting to avoid interference	TS 38.133 14 §8.1.5 Minimum requirement for UE turning off the transmitter: The transmitter power of the UE in the monitored cell shall be turned off within 40 ms after expiry of T310 timer as specified in TS 38.331.
T311 (RRC Re-establishment timer)	Time during which the 5G Mobile tries to re-establish RRC connection (cell selection, RACH, etc.)	TS 38.331 13 UE-TimersAndConstants Configurable to (ms): {ms1000, ms3000, ms5000, ms10000, ms15000, ms20000, ms30000}
RRC re-establishment / resume procedure latency (control-plane)	Once 5G Mobile tries to connect, how long until RRC connected state restored (if cell accepts)	TS 38.331 Table 12.1-1 UE Performance Requirements for RRC procedures for UEs: Processing times for RRC procedures are in the range 10-16ms, with RRCReestablishment taking 10ms

Therefore: in an ideal case (good coverage, cell available), a reconnection from RLF to RRC-CONNECTED can theoretically complete within a few **hundreds of milliseconds to a few seconds**, depending on the 5G Mobile, cell, and timer configuration.

But this is a *best-case/normative minimum*. In reality — high interference, cell load, need for new cell selection, RACH contention, mobility — reconnection may take **several seconds to many seconds (or more)**, and in the face of continuous interference, maybe not at all.

¹³ See 3GPP TS 38.331, NR; Radio Resource Control (RRC); Protocol Specification R15 (V15.30.0 2025)
https://www.3gpp.org/ftp/Specs/archive/38_series/38.331/?sortby=daterev

¹⁴ See 3GPP TS 38.133, Requirements for support of radio resource management R19 (V19.3.0 2025)
https://www.3gpp.org/ftp/Specs/archive/38_series/38.133/?sortby=daterev



The Global Language of Business

Maggie Lyons

Vice President, Government Affairs

GS1 US

June 4, 2026

Statement of GS1 US for the Committee on Energy and Commerce of the United States House of Representatives, Subcommittee on Communications & Technology Hearing:

“Where Are We?: Examining Positioning, Navigation, and Timing Capabilities in the United States”

GS1 US appreciates the opportunity to submit this statement for the record to the Committee on Energy and Commerce of the United States House of Representatives, Subcommittee on Communications & Technology of June 4, 2025.

GS1 US Interest

GS1 US is a neutral, not-for-profit standards organization with more than 300,000 members across 25 industries. We develop and maintain open, global standards that support supply chain operations across 25 industries, including retail, healthcare, logistics, manufacturing, and the public sector, rely on the open, global standards we develop and maintain with and for them. These standards include the GS1 UHF EPC Gen2, a global standard adopted by the International Standards Organization and governing passive RFID operations in the 902–928 MHz band.¹ Systems built on these standards are widely deployed across the United States and are relied upon daily to support inventory accuracy, product traceability, order fulfillment, safety, and regulatory compliance.

Organizations across the United States deploy systems built on these standards and rely upon them daily to help maintain inventory accuracy, ensure product traceability, and support safety. RFID technology provides unique, item-level identification and helps enable the automatic capture of precise data without the line-of-sight scanning required by barcodes.

¹ <https://www.gs1.org/standards/rfid/uhf-air-interface-protocol>



Because manufacturers have deployed RFID tags and related infrastructure to the GS1 UHF EPC Gen2 standard, organizations cannot easily retune or reprogram them. Additionally, tags are designed for long life; replacing the billions of tags already in use would be costly and time consuming.

GS1 US does not advocate for or against any particular communications or positioning technology. Our interest is ensuring that regulatory decisions affecting shared spectrum environments are based on rigorous, transparent testing that reflects real-world deployments and supports reliable conclusions about coexistence at scale.

Economic Impact

The RAIN Alliance, of which GS1 US is a member, recently commissioned an analysis to assess the economic consequences of NextNav's proposal. That analysis, conducted by Furchtgott-Roth Economic Enterprises, quantifies the economic impact on RAIN RFID users at between \$5.0 billion and \$7.2 billion, "in direct replacement costs—before accounting for substantial unquantifiable indirect costs and additional harms."²

Notably, those estimates also omit other key factors, including business disruptions, loss of supply chain data integrity, and costs to consumers.

That cost is a smaller subset of the larger economic impact. A separate study by the International Bridge, Tunnel, and Turnpike Association estimates that the "cost of retuning and replacing Part 15 devices alone is between \$27 billion and \$33 billion," as well as an additional cost to the tolling industry of at least \$6.8 billion.³

Together, these analyses show that changes to the Lower 900 MHz band affecting Part 15 users extend far beyond any single technology or user group, reaching tens of billions of dollars across interconnected systems.

² RAIN Alliance comment to FCC <https://www.fcc.gov/ecfs/document/103091335301841/1>

³ "An Economic Analysis of NextNav's Proposal for the Reallocation of Spectrum and the Modification of Rules in the Lower 900 MHz Band" <https://www.fcc.gov/ecfs/document/10428203750336/2>



It is also worth noting that deployments of RFID tags and readers continue to grow. In 2024, an estimated 52.8 billion RFID chips were shipped, a 17% increase over 2023.⁴ It is estimated that this year, there will be more than 1.7 million RFID readers installed across the country.⁵

Retail:

RFID use is widespread in the retail industry. Retail applications of RFID technology boost supply chain efficiencies by reducing excess stock, rework, and waste.

Additionally, RFID is a growing tool for law enforcement, as a means to detect and respond to product theft. RFID provides a highly efficient means of capturing serialized product data which enables law enforcement to understand who the rightful owner is of recovered items. A corporate executive highlighted this use in testimony before the Senate Committee on the Judiciary in a hearing in July of 2025 that RFID assisted in a recent investigation by Homeland Security Investigations: “RFID research revealed these stolen AEO items originated from 35 American Eagle stores across 13 states.”⁶ In the same hearing, he also stated that “[a]dvances in technology, including RFID, video surveillance analytics, and data-driven applications, are providing retailers with an unprecedentedly clear picture of the breadth and depth of organized retail crime.”

A shutdown of RFID systems would drive higher operational costs, reduce inventory accuracy, and delay critical supply chain processes, with direct consequences for both retailers and consumers.

Healthcare

The U.S. healthcare system is reliant on RFID technology, and disruptions to these systems could lead to serious operational and safety risks. RFID tracks and manages medical

⁴ RFID Journal Live, “RAIN Alliance Report Finds 2024 Tags Sales Approached 53 Billion,” March 4, 2025 <https://www.rfidjournal.com/news/rain-alliance-report-finds-2024-tags-sales-approached-53-billion/222992/>

⁵ <https://www.fcc.gov/ecfs/document/103091335301841/1>

⁶ <https://www.judiciary.senate.gov/imo/media/doc/2ac5e1ce-a44a-fc86-5b32-b49623cfd2d1/2025-07-15%20-%20Testimony%20-%20McBride.pdf>



devices, instruments, implants, consumables, and waste, enabling healthcare providers to deliver the right medications and devices to patients at the right time and to remove expired drugs from rotation.

GS1 Standards are widely used in healthcare and are cited in numerous regulations issued by the Food & Drug Administration. Although those regulations do not require the use of RFID, the FDA has piloted RFID applications. With disruptions to RFID, the FDA's efforts to streamline healthcare supply chains could experience major setbacks.⁷

Disrupting RFID systems could lead to errors and inefficiencies in inventory and delays in the delivery of medication. This could ultimately compromise patient outcomes and the overall quality of care provided by healthcare facilities.

Government

The U.S. government is an active user of RFID technology. Various departments use RFID technology in different ways. For example, the Department of War mandated case-level RFID tagging. GS1 US has worked with the Department on their "Identification Marking of U.S. Military Property" standard, also known as MIL-STD-130.⁸ This standard also discusses the use of tags and radio receivers for asset identification. GS1 Standards, as well as the benefits of RFID, are detailed in the United States Department of War Suppliers' Passive RFID Information Guide.⁹

RFID's value to military logistics is clearly demonstrated by the United States Marine Corps' Marine Corps Platform Integration Center (MCPIC).¹⁰ MCPIC "uses [passive RFID] to identify equipment and GPS to locate and track its position...assets are pRFID marked with appropriate tags and attributes are captured with pRFID tablets." Due to MCPIC, in 2022 "Marine Force Storage Command received a 100% audit rating on Military Equipment. Previously they had not been able to pass audit for that category of inventory."

The integration of RFID technology by the DoD underscores its importance and exemplifies U.S. government use. As the FCC considers the NextNav petition, it is imperative to

⁷ <https://www.fda.gov/media/168307/download>

⁸ https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=35521

⁹ https://www.acq.osd.mil/asds/log/docs/DoD_Suppliers_Passive_RFID_Info_Guide_v15update.pdf

¹⁰ https://rfidjournallive.com/wp-content/uploads/2023/06/May-10_315A_845_Supply_Prouse-1.pdf



The Global Language of Business

understand the significant benefits RFID provides to these and other departments. It is also important to consider the cost to taxpayers, and the loss of supply chain visibility to the Department of War that would result from NextNav's petition.

US Global Leadership

The United States is the world leader in RFID innovation and adoption, shaping the technologies and practices that underpin modern supply chains. Because RFID's value scales with adoption, leadership in this space enables American businesses to deploy the same standards and technology worldwide. A shift away from the widely used GS1 UHF EPC Gen2 standard would fracture global interoperability, weakening U.S. leadership and raising costs for U.S. businesses.

Conclusion

For the reasons outlined above, GS1 US is deeply concerned that approval of NextNav's petition would result in costly, industry-wide disruption. The heavy impact on Part 15 devices, including RFID, would impose steep costs on business and consumers alike, and could pose a significant challenge to military logistics. GS1 US appreciates the opportunity to provide these views and stands ready to serve as a technical and standards resource to the Commission and its staff as you consider the issues noted in the docket.

Respectfully submitted,

Maggie Lyons

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GS1 US