Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

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)	))))))	WT Docket No. 24-240

COMMENTS OF NEXTNAV INC.

September 5, 2024

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NextNav Inc. ("NextNav") respectfully submits these comments in response to the Federal Communications Commission's ("FCC" or "Commission") public notice[1] seeking comments on NextNav's proposed reconfiguration of the 902-928 MHz band ("Lower 900 MHz Band").[2] NextNav urges the Commission to issue a Notice of Proposed Rulemaking to reconfigure the Lower 900 MHz Band to enable a 5G terrestrial positioning, navigation, and timing network that can serve as a complement and backup to the U.S. Global Positioning System and to support 5G wireless broadband internet access. NextNav is committed to engaging with all stakeholders about its proposal and, in these comments, provides some answers to the Commission's initial questions.

INTRODUCTION

The functioning of modern society relies in no small part on access to reliable positioning, navigation, and timing ("PNT"), in particular the government-funded and government-operated Global Positioning System ("GPS"). While Americans now count on GPS throughout their daily lives—expecting it will be available to provide accurate walking and driving directions, track

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[1] *Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on NextNav Petition for Rulemaking*, Public Notice, WT Docket No. 24-240, DA 24-776 (rel. Aug. 6, 2024) ("Public Notice").

[2] Petition for Rulemaking of NextNav Inc., WT Docket No. 24-240 (Apr. 16, 2024), https://www.fcc.gov/ecfs/document/10416238018537/1 ("Petition").

rideshare and delivery services, and allow first responders to quickly locate them in an emergency[3]—few are aware that much of the nation's critical infrastructure also relies on GPS. Financial systems depend on GPS to provide accurate timestamps to time transactions.[4] Electrical grids use GPS timing information for everything from transmission-line fault detection to substation control.[5] And telecommunications networks rely on GPS for the network synchronization needed to ensure smooth and reliable communications links.[6] For these reasons and more, GPS is critical to U.S. national security.[7] In 2019, the National Institute of Standards and Technology ("NIST") issued a report estimating that "the loss of GPS service would have a $1 billion per-day impact."[8] And yet, in the event of a disruption to GPS or other satellite-based systems, the United States, unlike its global competitors, has no terrestrial PNT ("TPNT") backup.[9]

NextNav has proposed to deploy a commercial TPNT backup and complement to GPS by rationalizing the Lower 900 MHz Band. While ensuring coexistence with licensed incumbent operations, NextNav would use the reconfigured Lower 900 MHz Band to partner with network

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[3] *See, e.g.*, *A Brief History of GPS*, Aerospace Corp., https://aerospace.org/article/brief-history-gps (last visited Sept. 3, 2024); Appendix A: Resilient Positioning, Navigation, and Timing for Public Safety.

[4] *See* Tim Fernholz, *The Entire Global Financial System Depends On GPS, and It's Shockingly Vulnerable To Attack*, Quartz (Oct. 22, 2017), https://qz.com/1106064/the-entire-global-financial-system-depends-on-gps-and-its-shockingly-vulnerable-to-attack.

[5] *See* James Carroll & Kirk Montgomery, *Global Positioning System Timing Criticality Assessment – Preliminary Performance Results*, 492-96 (2008), https://rntfnd.org/wp-content/uploads/2013/09/GPS-Timing-Criticality-Volpe-Paper-2008.pdf; North American SynchroPhasor Initiative, *Time Synchronization in the Electric Power System*, 3 (Mar. 2017), https://www.naspi.org/sites/default/files/reference_documents/tstf_electric_power_system_report_pnnl_26331_march_2017_0.pdf.

[6] Ed Butterline & Sally Frodge, *Telecommunications Synchronization and GPS*, 5 GPS Solutions 51 (2001), https://doi.org/10.1007/PL00012876.

[7] Selam Gebrekidan et al., *Why GPS Is Under Attack*, N.Y. Times (July 2, 2024), https://www.nytimes.com/interactive/2024/07/02/world/gps-threats.html.

[8] Alan C. O'Connor et al., *Economic Benefits of the Global Positioning System (GPS): Final Report*, RTI Int'l, ES-4 (2019), https://www.nist.gov/system/files/documents/2020/02/06/gps_finalreport618.pdf.

[9] Marc J. Berkowitz, *America's Asymmetric Vulnerability to Navigation Warfare: Leadership and Strategic Direction Needed to Mitigate Significant Threats*, Nat'l Sec. Space Ass'n (July 18, 2024), https://nssaspace.org/wp-content/uploads/2024/07/NAVWAR-FINAL.pdf ("*Navigation Warfare*").

providers interested in commercial broadband deployment of the Lower 900 MHz Band for 5G broadband. The partners would have the market incentive to deploy 15 megahertz of low-band spectrum for 5G broadband, and NextNav would thereby leverage the 5G-network infrastructure to make the incremental investments necessary for a widescale implementation of next-generation TPNT. By updating the Lower 900 MHz Band plan and its service rules and allowing NextNav to exchange its current Lower 900 MHz holdings to make 15 megahertz available nationwide, Americans would receive the public good of a widely accessible TPNT network worth billions of dollars when there is otherwise no economically viable plan on the horizon to create such a network.

Rationalizing the Lower 900 MHz Band not only puts the Lower 900 MHz Band to its highest and best use, but also can require the licensee—NextNav in this case—to enable a TPNT complement and backup to GPS that the United States has long identified as a public interest imperative.[10] The benefits of this proposal span industries and stakeholders. Those benefits include:

National security. Resilience against PNT service disruption or manipulation is an important security and economic concern for the United States. For that reason, the U.S. Department of Transportation has called for a "system-of-systems" for PNT, which would complement GPS and provide a backup in the event of an outage.[11] Many of America's foreign allies—and rivals—have already deployed domestic terrestrial complements and backups to their

[10] *See, e.g.*, *U.S. Space-Based Positioning, Navigation, and Timing Policy*, GPS.gov (Dec. 15, 2004), https://www.gps.gov/policy/docs/2004/.

[11] U.S. Dep't of Transp., *Complementary PNT Action Plan: DOT Actions to Drive CPNT Adoption* (Sept. 2023), https://www.transportation.gov/sites/dot.gov/files/2023-09/DOT%20Complementary%20PNT%20Action%20Plan_Final.pdf (*"CPNT Action Plan*").

respective global navigation satellite systems ("GNSS").[12] China, for example, has integrated its GNSS with Ground-Based Augmentation Systems ("GBAS") and terrestrial radio beacons to transmit additional navigation signals.[13] In contrast, the United States has no such system, no allocated funding, and no practical plan to create one in the future. NextNav's proposal offers an opportunity not only to enable a long-sought terrestrial backup and complement to GPS, but also to leapfrog foreign rivals' technologies using a standards-based approach that enables rapid adoption and does not require American taxpayers to foot the bill.

Public safety. All nationwide commercial mobile radio service ("CMRS") providers generally must provide x/y-axis information within 50 meters for at least 80% of wireless E911 calls, and those that provide z-axis information must be accurate within 3 meters for at least 80% of wireless E911 calls.[14] There are many instances where technology is challenged to consistently provide the needed level of accuracy—in particular, indoors, especially in tall buildings, and in urban canyons. NextNav's NextGen solution can provide x/y location accuracy down to 10 meters or less, along with z-axis down to 3 meters.[15] NextNav's next-generation TPNT implementation promises more accurate location readings and, by extension, more timely emergency responses. The planned deployment will also enable more reliable emergency-call routing by providing the kind of timely and granular location information needed to ensure emergency calls are routed to the proper public safety answering point. Other technologies can suffer from limitations or

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[12] *See Navigation Warfare* at 13.

[13] Rear Admiral David Simpson, *A Day Without Space and a Call for Greater Positioning, Navigation, and Timing Resiliency in the United States*, Wireless @ Virginia Tech (Sept. 3, 2024), https://wireless.vt.edu/news/a-day-without-space-simpson.html ("*A Day Without Space*").

[14] *See* 47 C.F.R. §§ 9.10(i)(2)(i)(A), 9.10(i)(2)(ii)(H).

[15] For the supporting assumptions, *see* Petition, at Exhibit A – Technical Appendix, A-9 (noting that calculations depend on the methodology, network configuration, path loss, and fading channel model as described in 3GPP TRs 37.857 and 38.855).

vulnerabilities that would not affect a TPNT system.[16] Greater and more reliable location accuracy not only helps ensure continuity of service to end users, but also allows for heightened situational awareness for first responders: The capacity of an incident commander to know a team's location as well as the ability of every first responder to know the way into—and out of—hazardous conditions can mean the difference between life and death. The white paper attached as Appendix A provides additional detail on how public safety agencies use PNT, and how NextNav's next-generation solution can meet those needs.

Adoption and use. NextNav intends to leverage the widespread availability of 5G network operations throughout the United States to deploy TPNT in the Lower 900 MHz Band using 5G NR-standard positioning reference signals ("PRS"). Building on the established and vibrant 5G device ecosystem will allow for the rapid introduction and wide adoption of consumer-friendly user equipment that can receive PNT services through PRS on the rebanded 900 MHz frequencies. And operating within the 3GPP standard will help the service to avoid the struggles with deployment and adoption that other PNT technologies have experienced.[17]

Broadband engine. Reconfiguration of the band results in 15 megahertz of low-band spectrum for the deployment of wireless broadband internet access services. NextGen TPNT needs to realize economies of scale to support widespread deployment. Absent massive

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[16] For example, most 911 calls rely on device-based-hybrid ("DBH") technology to provide location accuracy. While a powerful tool, DBH accuracy and performance depends on the context in which it is operating. Existing DBH solutions rely on assembling as much data as possible from the surrounding environment as a means of identifying location. Sensory data that can be cross referenced to known location information might include GPS data, WiFi, Bluetooth, cell site triangulation, terrestrial beacons, barometric pressure sensors, and data from other on-device systems. Especially in environments with limited or compromised electronic activity, DBH accuracy and performance can suffer. In large-scale emergencies, for example, building power can fail or become disabled, which limits the availability of several important DBH data sources. NextNav's NextGen TPNT system, however, can work as a system-of-systems to deliver a high level of location accuracy and performance even in compromised environments where WiFi or Bluetooth locations become unavailable or where reliable satellite-based timing data makes accurate location information difficult or impossible to calculate.

[17] *See, e.g.*, Robert Huntley, *Are We Over-Dependent on GNSS?*, EE Times (Nov. 1, 2023), https://www.eetimes.eu/are-we-over-dependent-on-gnss/.

government intervention or taxpayer support, a widescale, sustainable TPNT deployment will need to have a much lower cost of deployment than the cost of a standalone, greenfield build. The best, and likely the only, mechanism for TNPT to prove financially viable at scale is to access the healthy ecosystem of infrastructure, semiconductors, devices, applications and mobile support services that 5G NR offers, combined with a widescale 5G broadband network deployment. Standard-sized, contiguous uplink and downlink band segments—together with robust network infrastructure to ensure sound coverage indoors and out—represent two vital building blocks for any 5G deployment. Establishing a 5+10 megahertz configuration in the Lower 900 MHz Band will thus not only help make TNPT deployment economically sustainable, but also create a path for TNPT operations to evolve as 5G advances to 6G and beyond. The capacity required to transmit PRS signals to enable high quality reliable PNT is projected as 2-5% of the downlink capacity, so there is little impact to the availability of, and incentive to deploy and operate, 15 megahertz for 5G voice and data.

The public interest benefits of this proposal are enormous. The United States will enjoy access to a privately funded, consumer friendly TPNT deployment to serve as a much-needed complement and backup to GPS, with a clear path to widespread adoption. Consumers will also enjoy additional resources for broadband internet access services in an environment in which spectrum, especially low-band spectrum, is increasingly scarce. NextNav has already started working with numerous incumbents to ensure coexistence with licensed users in the Lower 900 MHz Band, including through appropriate financial and technical support. And unlicensed users will continue to operate in the band. The alternative—continuing to lumber along without any means to protect vital safety-of-life and quality-of-life services against GPS outages and coverage gaps—offers many more risks and none of the benefits of innovation and investment that NextNav's proposal promises to deliver.

I. NEXTNAV CAN MEET THE URGENT NEED FOR A TERRESTRIAL PNT SYSTEM TO COMPLEMENT AND BACK UP GPS IN THE UNITED STATES.

Although GPS is the backbone of American society, it is vulnerable to a variety of threats. As Rear Admiral David Simpson explains, these threats include:

> *Jamming*: Intentional interference with GPS signals can disrupt or block reception, effectively rendering PNT services unusable in affected areas. This can be achieved using relatively inexpensive equipment, making it a readily accessible tactic for malicious actors.
>
> *Spoofing*: Malicious actors can broadcast fake GPS signals, causing receivers to display inaccurate positioning data. This can be particularly dangerous for navigation applications, potentially leading to accidents and misdirection.
>
> *Cyberattacks*: Adversaries may target the infrastructure supporting GPS, such as ground control stations or satellites, potentially disrupting service or manipulating data. The increasing sophistication of cyberattacks makes GPS infrastructure a potential target.
>
> *Kinetic Attack*: Counter-space capabilities continue to improve. Nations that possess the ability to launch satellites in orbit, can develop the ability to damage or destroy satellites with an anti-satellite weapon. Advanced counter-space capabilities include the ability to take out whole constellations, generating a debris field that would make re-constitution problematic. At the high end, use of a variety of nuclear weapons could generate a range of significant and lasting damage.
>
> *Electro-Magnetic Pulse Weapons*: This category of counter-space weapons is intended to generate high, pulsed energy electro-magnetic radiation that can disrupt or destroy satellite electronics.
>
> *Severe Space Weather Events*: Solar activity is constantly changing. The strongest solar events can disrupt, destroy and even de-orbit satellites. Many of the event categories impact multiple satellites across a wide area all at once. Strong Solar Flares and Coronal Mass Ejections (CME) can disrupt satellite radio communications, and in their most intense form, damage satellite electronic components and interfere with receiver equipment receipt of signals on earth.[18]

[18] *A Day Without Space* (footnotes omitted); *see also* U.S. Gov't Accountability Off., GAO-21-320SP, *Technology Assessment: Defense Navigation Capabilities: DOD Is Developing Positioning, Navigation, and Timing Technologies to Complement GPS* (May 2021), https://www.gao.gov/assets/gao-21-320sp.pdf; Vivek Mukherji &

These and other hazards have prompted the U.S. Department of Transportation ("DOT"), as the chief civilian authority on PNT, to call for a "system-of-systems" approach to PNT.[19] DOT has recognized the need to complement and back up GPS, and recently awarded NextNav funding to support experimental stress testing of its PNT technology. In September 2023, DOT released a Complementary PNT ("CPNT") Action Plan, laying out several actions it plans to take to facilitate increased CPNT usage.[20] The plan highlights the actions DOT plans to take over the next several years to promote complementary PNT systems such as NextNav's. As part of the action plan, the DOT in March 2024 requested proposals for CPNT technologies for instrumentation, testing, and evaluation at field test ranges in conjunction with critical infrastructure owners and operators. In June 2024, after receiving 29 proposals, the Department awarded $7.2 million to nine technologies to participate in the field testing.[21] NextNav received an award of $1.9 million. The testing and evaluation will take place over the next year with the goal to facilitate adoption of the technologies into federal systems that require improved PNT resiliency. Those technologies that meet DOT standards, including handling interference that can affect GPS, will be placed in a federal clearinghouse of potential technology options to back up GPS that federal agencies can begin to procure.

DOT's leadership has highlighted the pressing need for critical infrastructure to have access to a backup to GPS, and the DOT program awards represent an important step to integrate

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AKS Chandele, *GNSS Jamming: An Omnipresent Threat*, Geospatial World, https://www.geospatialworld.net/prime/special-features/gnss-jamming-an-omnipresent-threat/ (last visited Sept. 2, 2024); Cybersecurity & Infrastructure Sec. Agency, *Understanding Vulnerabilities of Positioning, Navigation, and Timing*, https://www.cisa.gov/sites/default/files/publications/fact_sheet_pnt_vulnerabilities_508.pdf.

[19] *CPNT Action Plan* at 5.

[20] *See generally id.*

[21] U.S. Dep't of Transp., *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.

complementary PNT services into federal platforms. But realizing the vision of a resilient backup and complement to GPS will require a whole-of-government effort alongside robust commercial deployments that are cost-effective, scalable, dynamic, and sustainable.

A. NextNav's NextGen Solution Has the Characteristics and Capabilities Needed to Function as a PNT Complement and Backup to GPS.

NextNav is uniquely positioned to offer a PNT system capable of serving as a complement and backup to GPS. In 2021, DOT published a report about what kind of PNT features are needed to offer backup capability in the event of disruption to GPS.[22] The 2021 DOT Report identified 14 metrics to be used to assess the effectiveness of a PNT system, which are:

1. the technical readiness of the system;
2. the technical readiness of the user equipment leveraged by the system;
3. timing and positioning accuracy;
4. regulatory aspects of the spectrum;
5. the cost of the system, for example in terms of time and materials needed;
6. a scalar representation of the infrastructure needs of the system per coverage area;
7. the traceability of the timing solution;
8. the strength of signal reception under nominal operating conditions;
9. the system service response to off-nominal or changing conditions;
10. the type of PNT system being used, e.g., whether terrestrial or satellite based;
11. the system compatibility with GPS and other PNT systems and the layering of services;
12. the security level of information in the system, as dictated by the use of encryption, authentication or other security techniques;

[22] Andrew Hansen et al., U.S. Dep't of Transp., *Complementary PNT and GPS Backup Technologies Demonstration Report: Sections 1 through 10*, DOT-VNTSC-20-07 (Jan. 2021), https://www.transportation.gov/administrations/assistant-secretary-research-and-technology/complementary-pnt-and-gps-backup ("2021 DOT Report").

13. timeframe needed to implement service for the system; and

14. the projected operating lifetime of the system.[23]

The 2021 DOT Report ranked NextNav's present-generation PNT technology as best in class under a variety of scoring methods.[24] After evaluating 11 different PNT technologies, DOT concluded that while all "demonstrated some PNT performance of value . . . only one vendor, NextNav, demonstrated [PNT performance] in all applicable use case scenarios."[25] Building on its proven PNT foundation, NextNav will work with industry and leverage the existing 5G infrastructure and device ecosystem to deliver a widespread and accessible TPNT service that can serve as a backup and complement to GPS.

B. NextNav's Proposal Is a Private Sector, Widescale Approach Without a Cost Burden to Taxpayers.

NextNav's 5G mobile network operator ("MNO") partner(s) will have strong commercial incentives to deploy the Lower 900 MHz Band for wireless broadband services. As explained in its Petition, NextNav's proposal relies on these strong commercial incentives to lower the cost of deploying a state-of-the-art, 5G TPNT system and create a pathway for continued investment and innovation over time. In the 2021 DOT Report, one category in which the NextNav system underperformed was cost because the widespread implementation of present-generation NextNav technology would be prohibitively high absent large subsidies, due to the need for a standalone network dedicated solely to support TPNT services.[26] Fortunately, the Petition solves this problem. The advantage of NextNav's NextGen system is that it largely relies on existing cellular infrastructure to achieve backup TPNT coverage and enhanced public safety benefits accessible to

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[23] *See id.* at 149–79.

[24] *See generally id*.

[25] *Id.* at 194.

[26] *See id.* at 160–64.

all compatible user equipment across much of the United States. NextNav will partner with one or more 5G network providers to implement its technology on the provider's (or providers') existing cell sites, while also making 15 megahertz available for 5G applications and use cases. As a result, no federal taxpayer dollars need be spent, and availability can be widespread (unlike many other systems based on PNT-specific standards).

NextNav's plans to deploy its TPNT network under a partnership with 5G providers will reduce deployment costs by leveraging the partner's existing infrastructure and assets to enable widescale TPNT services running on the Lower 900 MHz 5G Band. MNOs update and upgrade their network for multiple reasons, such as new band integration (e.g. C-band), upgrading the technology (e.g. LTE to 5G, or 5G Non-Standalone to 5G Standalone), to expand their coverage, and to improve their mobile services. Hence, the cost of the new Lower 900 MHz TPNT 5G network will be much less than that of a greenfield, sole-source, TPNT-only deployment.

Among AT&T, Verizon Wireless, and T-Mobile, approximately 98% of the U.S. population, 77% of road miles, and 55% of square miles are covered by at least one provider of 5G.[27] Accessing deployed infrastructure, TPNT coverage is expected to have a similarly broad reach once fully implemented. And critically, because of the use of standards-based, mass-market 5G technologies, this service will be accessible by a maximum number of end-users. NextNav already provides z-axis coverage in 90% or more tall buildings in about 4,400 cities in the United States.[28] NextNav's partnership model provides a strong foundation for a rapid and economically

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[27] *In re 2022 Communications Marketplace Report*, 2022 Communications Marketplace Report, 37 FCC Rcd 15514, 15624 ¶ 149 (2022), https://www.fcc.gov/document/2022-communications-marketplace-report.

[28] Press Release, NextNav, *NextNav's Vertical Location Service Now Available In Fifty US Markets* (Nov. 24, 2020), https://www.prnewswire.com/news-releases/nextnavs-vertical-location-service-now-available-in-fifty-us-markets-301179373.html; NextNav, *Summary of 'Report on Stage Z'* (July 23, 2018), https://nextnav.com/wp-content/uploads/2021/03/NextNav-CTIA-Excerpt-Final.pdf.

sound deployment of TPNT coverage accessible by the greatest number of consumers and businesses.

Similar to other 5G networks, the NextGen network will observe the standard technical parameters under the Commission's Part 27 flexible-use rules for mobile and fixed broadband operations. NextNav has proposed modifications to the multilateration Location and Monitoring Service ("M-LMS") technical rules to align with the Part 27 specifications.[29] These proposed technical parameters are summarized in Table 1 below.

Rule	Proposed Rules	
	Rule Part	Rule
ERP Limit	90.1408(a)	1000 W/MHz and 305 meter HAAT Higher HAAT allowed at reduced power per Table 1
ERP Limit in Counties with less than 100 POPs per sq mile	90.1408(b)	2000 W/MHz and 305 meter HAAT in 918-928 MHz Higher HAAT allowed at reduced power per Table 2
Mobile and Portable ERP Limit	90.1408(c)	3 W in 902-907 MHz
Emission Limits	90.1409(a)	43+10log(P) in 100 kHz RB In first 100 kHz, RB can be 30 kHz

Table 1 Summary of principal system technical parameters[30]

The proposed rules open new opportunities for coexistence with other uses in the band. As one example, 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

[29] *See* Letter from Robert Lantz, General Counsel, NextNav Inc., to Marlene H. Dortch, Secretary, FCC, ECFS INBOX-1.401 (June 7, 2024), https://www.fcc.gov/ecfs/document/10607137757430/1.

[30] Although not specifically mentioned in the Rules Supplement document submitted by NextNav on June 7, 2024, NextNav expects that the ERP measurement procedure will be similar to the procedure in other sub-1 GHz Part 27 bands and will be based on maximum average power as described in, for example, sections 27.50(b)(11), 27.50(b)(12), and 27.50(c)(11) of the Commission's rules. 47 C.F.R. §§ 27.50(b)(11), 27.50(b)(12), 27.50(c)(11).

other sub-1 GHz bands.[31] Using a PSD limit is significant because doing so can cause the resulting maximum average radiated power to be *less than* the power allowed under the existing power limit for the Lower 900 MHz Band found in section 90.205(l) of the Commission's rules. The existing rule sets a limit on each emission, and the emission bandwidth is not limited; therefore, Multilateration LMS licensees may deploy a maximum average radiated power that is limited only by the number of emissions in the band. For example, a Multilateration LMS licensee could deploy 80 channels per megahertz, with each channel 12.5 kilohertz wide and limited to 30 watts peak ERP. Conservatively assuming a peak to average ratio of 2 dB, this results in maximum average ERP of 18.9 watts per channel. Across 80 channels, this value equates to an ERP of more than 1,500 watts/MHz, which is greater than 50% *more* power per megahertz than NextNav has sought in its proposed modification of section 90.1408(a) of the Commission's rules.

In addition, the radiated power limit in the 5-megahertz uplink segment proposed by NextNav would be significantly less power than is currently allowed, even if the current M-LMS licensee deploys only a single emission. This is because, using the same peak-to-average ratio as above, a single emission is allowed to transmit at a maximum average radiated power of 18.9 watts, whereas NextNav has proposed a mobile ERP limit of 3 watts across the entire 5 megahertz. Under

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[31] The Commission repeatedly has adopted ERP limits based on PSD measurements and applied average rather than peak power limits to operational terrestrial wireless services in order to account for the industry's use of wider emission bandwidths. *See, e.g., In re Biennial Regulatory Review – Amendment of Parts 1, 22, 24, 27 and 90 to Streamline and Harmonize Various Rules Affecting Wireless Radio Services*, Third Report and Order, 23 FCC Rcd 5319 (2008) (changing power limits to PSD for the PCS and AWS bands) ("*Wireless Streamlining Order*"); *In re Amendment of Parts 1 and 22 of the Commission's Rules with Regard to the Cellular Service, Including Changes in Licensing of Unserved Area*, Second Report and Order, Report and Order, and Second Further Notice of Proposed Rulemaking, 32 FCC Rcd 2518 (2017) (changing power limits to PSD for the cellular band). In the *Wireless Streamlining Order*, for example, the Commission agreed with claims in the record that "systems operating in narrower bandwidths are effectively permitted to operate with higher power spectral densities than those operating in wider bandwidths" and adopted PSD-based limits instead of the prior radiated power rules for PCS and AWS that had "measure[d] EIRP per emission, and limit[ed] base station power—regardless of bandwidth size—to 1640 watts peak EIRP for antenna heights up to 300 meters height above average terrain (HAAT) (3280 watts peak EIRP for rural areas)." *Wireless Streamlining Order*, 23 FCC Rcd at 5324-25 ¶ 12.

the current rules, multiple emissions of 18.9 watts are allowed, which could significantly increase the power spectral density in the lower part of the band.[32] Also, in reality, 900 MHz handheld mobile devices will transmit at significantly less power than proposed since standard 3GPP conducted power for mobile devices is 200 milliwatts (23 dBm) and mobile devices typically have negative antenna gain, especially when transmitting at sub-1 GHz frequencies.

Therefore, the total power radiated by NextNav in the lower part of the band will be orders of magnitude less than the power that is allowed under the current rules. In each of its proposed rule changes, including the PSD-based assessments, NextNav has sought to replicate the Part 27 rules in the Lower 900 MHz Band because leveraging MNO partners' existing network infrastructure is the key to enabling a widescale TPNT network on a national scale.

C. The Lower 900 MHz Band Is Well-Suited for a Terrestrial PNT System.

The Commission asks whether other bands should be considered for PNT operations.[33] The contiguous spectrum available in the Lower 900 MHz Band is ideally suited for next-generation TPNT. The proposed 5+10 MHz configuration will allow high-performance PNT and 5G consistent with 3GPP standards. Furthermore, the Lower 900 MHz Band has ideal propagation characteristics for indoor use. The Lower 900 MHz Band travels long distances and penetrates buildings better than comparably powered higher frequency transmissions can. A 900 MHz operation can therefore minimize PNT dead zones indoors and in densely populated areas where buildings can block reception, while also reducing the cost of deployment. The Lower 900 MHz

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[32] While NextNav expects that most of the devices operating in the band will be handheld portable mobile devices, the 3-watt uplink ERP limit is consistent with other sub-1 GHz Part 27 bands (see, for example, section 27.50(c)(10) of the Commission's rules, 47 C.F.R. § 27.50(c)(10)) and allows for additional use cases such as fixed wireless access.

Band also allows NextNav to leverage its MNO partners' existing cellular base station infrastructure and the standard 5G user equipment design and form factor.

NextNav already uses the band to provide some TPNT services with its present-generation technology. And although other bands could theoretically support TPNT operations, no other band has been identified for TPNT use, and broadband operators have understandably used their spectrum capacity for broadband instead of TPNT services. In a market environment where GPS provides accurate geolocation much of the time at no cost to the user, the incentives for an MNO to deploy a standalone TPNT system of its own are limited, at best.

As a leading provider of TPNT services in the United States, however, NextNav has developed many core TPNT innovations as an integral part of its business developing and operating the company's present-generation TPNT technology, which has earned distinction from multiple third-party validators, including the DOT.[34] Combining NextNav's core TPNT capabilities and know-how with the planned 5G network using standards-based 5G network equipment and devices will help ensure a reliable and resilient backup to GPS where and when it is needed most.

NextNav is poised to deploy a 5G-capable TPNT infrastructure on its licensed spectrum in the Lower 900 MHz Band. NextNav's system is being designed from the outset to produce and distribute TPNT signaling which is synchronized independent of GPS-based systems. The proposed spectrum reconfiguration will allow the planned deployment to serve more people more efficiently and with more accurate TNPT than otherwise possible.

Having TPNT supplied by an operator focused on TPNT solutions rather than an operator focused on running a broadband service business overcomes one more challenge that has bedeviled

[34] *See supra* Section I.A.

private-sector TPNT solutions for years: a persistent collective action problem. Not every wireless operator in the United States needs to deploy PRS-signaling information to ensure a complement and backup to GPS exists. But at least one operator *should* deploy a TPNT system independent of GPS to provide the public good of resiliency and redundancy to communications networks and other critical infrastructure. Even though all mobile network operators—and, indeed, the entire country—stand to benefit from the deployment of a complement and backup to GPS, it may not be economically rational for a wireless operator to incur the risk and expenses of deploying a TPNT system on its own. NextNav's proposal solves this challenge, too. It uses the incentive for incremental 5G broadband deployment as a mechanism to support TPNT, incentivize deployment, and promote widescale TPNT service for the United States.

To make NextNav's proposal for an accurate, reliable TPNT service a reality, NextNav requires 15 megahertz in which NextNav would deploy 5G NR PRS. PRS benefits from using resource elements spread across all available 5G NR downlink bandwidth and then transmitting PRS over multiple symbols that can be aggregated to assemble a more accurate reading.[35] Rather than operating in one band sub-segment, PRS signals are scattered throughout the available downlink band for each transmitting base station, as if occupying squares on a checkerboard. The dispersion of PRS resource elements across the downlink of multiple base stations according to a common pattern produces several benefits. First, the PRS pattern allows for an accurate and resilient estimate of ranges and distances essential to PNT. Second, comb patterns of PRS transmissions where different base stations transmit different PRS patterns at the same time in combination with PRS muting patterns enable efficient transmission with low interference. Third,

[35] Satyam Dwivedi et al., *5G Positioning: What You Need to Know*, Ericsson (Dec. 18, 2020), https://www.ericsson.com/en/blog/2020/12/5g-positioning--what-you-need-to-know.

repetition of the PRS signal in a pattern allows for the accumulation of power and makes the signal easier to detect. Wider bandwidths help overcome multipath interference, which poses a substantial challenge in cluttered environments. As NextNav explained in the Petition, "a wider signal bandwidth can separate more tightly spaced multipath since a larger bandwidth in the frequency domain enables a finer time domain."[36] Reducing multipath interference through wider bandwidths generates better range accuracy and, in turn, a more accurate positioning and timing solution for the end user.

Again, even with this robust PRS transmission designed to overcome interference and enhance accuracy, NextNav expects it will still require only 2-5% of the downlink resource blocks to support its next generation TPNT with geolocation accuracy indoors and in high density areas on an x/y-axis down to 10 meters and timing accuracy less than 20-nanoseconds. The remaining 95%-plus of downlink resource blocks will support TPNT base station deployment and help scale adoption and use by being made available for 5G broadband service.

Finally, there is little to no low-band spectrum readily available due to extensive encumbrances throughout the low-band frequency range and the undesirable propagation characteristics of frequencies below the 600 MHz range for intensive frequency reuse. While it may be possible to combine TPNT in the Lower 900 MHz Band with TPNT operations in other bands one day, the Lower 900 MHz Band represents the most logical starting point to provide TPNT services.

[36] Petition at Exhibit A – Technical Appendix, A-8.

II. NEXTNAV'S PROPOSAL WOULD FURTHER ENHANCE WIRELESS E911 LOCATION ACCURACY.

Today, Americans expect that when they call 911, dispatchers and first responders will be able to see their location with accuracy. The reality is more complicated. A number of factors undermine 911 caller location accuracy. Most notably, GPS does not work as well indoors or in dense urban environments, which is of course where many 911 calls are placed.[37] As a result, one NIST study found that the vast majority of first responders report an "inability to accurately track caller location" always, most of the time, or some of the time.[38] Not only are dispatchers unable to consistently and accurately track callers, but first responders also struggle to maintain their own situational awareness when entering dangerous environments.[39]

While NextNav currently provides location accuracy service using its B and C Block licenses, the NextNav NextGen solution will offer greater accuracy and higher reliability on a much larger scale than possible today, and significantly enhance emergency services in the following key ways:

> *Enhanced location accuracy*. Similar to GPS, the NextGen TPNT system can provide highly accurate location data and can do so in more places than GPS (e.g., in urban canyons).
>
> *Improved location-based routing*. With better location data, calls can be efficiently routed to the appropriate Public Safety Answering Point (PSAP), minimizing the need for call transfer among multiple PSAP jurisdictions.
>
> *Z-axis availability and accuracy*. The NextGen TPNT system can incorporate barometric pressure sensors to provide precise altitude data, allowing the first responders to pinpoint the exact floor within a building.

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[37] Shanée Dawkins et al., Nat'l Inst. of Standards & Tech., U.S. Dep't of Commerce, NISTIR 8400, *Voices of First Responders—Nationwide Public Safety Communication Survey Findings: Day-to-Day Technology, Phase 2*, Volume 3, 27 (Oct. 2021), https://nvlpubs.nist.gov/nistpubs/ir/2021/NIST.IR.8400.pdf.

[38] *Id.*

[39] First Responder Smart Tracking Challenge, *Come with Us to the Cutting Edge*, https://frstchallenge.com/ (last visited Sept. 4, 2024).

Situational awareness. First responders and incident commanders can better visualize the incident scene, enhancing coordination and decision-making.

Enhanced indoor coverage. For subscribers inside buildings where GPS signals might be weak, the NextGen TPNT system with indoor positioning capability can help to refine location data. With TPNT technology in the E911 system, emergency services can offer more accurate, timely, and efficient assistance, improving outcomes for the public.

A. Under Its Proposal, NextNav Would Continue to Provide Location Accuracy Services.

NextNav's business is providing superior location accuracy services. NextNav has chosen to concentrate on TPNT service delivery to differentiate itself in the market and deliver higher-quality services, greater customer satisfaction, and a stronger brand identity. As a result, NextNav anticipates that if the Commission were to adopt NextNav's proposal, the new or modified licenses would be subject to new rules that include new performance requirements as well as new requirements for TPNT coverage coincident with the scope of 5G deployment. NextNav would also readily accept TPNT use obligation and buildout obligation conditions to enable TPNT services using 5G NR PRS or other standards-based technologies that might succeed 5G NR PRS as part of an Order and Authorization.[40] NextNav already is pursuing quality TPNT; a TPNT condition would simply ratify and affirm NextNav's existing mission. For the same reason, the current condition on Progeny's B and C Block licenses requiring Progeny to "continue to provide location accuracy services on all of its B and C Block licenses for at least a five (5) year period ending April 3, 2028" should not hinder rationalization of the band. In a notice of proposed rulemaking, the Commission can propose to remove this condition in the event that it reconfigures the Lower 900 MHz Band so that the B and C Block licenses no longer exist.

[40] *See infra* at V.A.

B. The Consumer 5G Ecosystem Will Help Scale NextNav's NextGen TPNT Solution.

Combined with the network coverage benefits of associating its TPNT solution with 5G broadband, the robust consumer 5G ecosystem will help ensure NextNav's TPNT solution is widely available. The Commission asks about the commercial availability of mobile devices that could support NextNav's technology.[41] As explained above, the TPNT service's PRS signals can be made available to all compatible user equipment. While Lower 900 MHz 5G devices are not yet commercially available because the band has not yet been standardized, NextNav plans to work with its 5G partner(s) to make devices rapidly available through the 5G ecosystem. The first step to commercialization would start with a band plan work item at 3GPP, which is typically a six-to-nine-month process.[42] NextNav does not see any significant challenges in standardizing the band.

Because NextNav's proposed band is a new band plan, device manufacturers will have to add hardware support for the new band to access NextNav's TPNT/5G network. Adding device hardware support for new bands happens recurrently in the industry, and modern device hardware is designed to be multi-band capable.[43] These future 900 MHz devices would also need to support the PRS feature in 5G, which can be readily activated with a software enhancement.[44] Commercial

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[41] Public Notice at 3.

[42] 3GPP, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; US 600 MHz Band for LTE; (Release 15)*, 3GPP TR 36.755 V15.0.0 (2017-09) (2017), https://www.3gpp.org/ftp//Specs/archive/36_series/36.755/36755-f00.zip at Annex A ("TR 36.755, 3GPP Technical Report, Annex A") (showing that 3GPP added a new Band Class 71 to support the 600 MHz band in about five months).

[43] *5G and LTE. Find the iPhone That's Right for Your Country or Region.*, Apple, https://www.apple.com/iphone/cellular (last visited Sept. 5, 2024) (showing that the latest iPhone 15, released September 2023, supports 31 LTE bands and 30 5G bands); *Technical Specifications*, Apple, https://support.apple.com/en-us/111973 (last visited Sept. 5, 2024) (showing that the iPhone 5s, released ten years earlier in September 2013, supported no more than 13 LTE bands).

[44] 3GPP, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN (Release 18)*, 3GPP TS 38.305 V18.2.0 (2024-06), 3GPP (2024), https://www.3gpp.org/ftp/Specs/archive/38_series/38.305/38305-i20.zip.

device support for a band is usually driven by business and economic factors. NextNav's future network partners' scale, along with TPNT market drivers, will be an asset in advancing device support for the new band. T-Mobile's Band 71 (i.e., the 600 MHz band) is a good example of how motivated parties can accelerate new band plan support for devices. The first Band 71 smartphone came out in October 2017,[45] shortly after the completion of the incentive auction and 3GPP approval of the band that September.[46] NextNav and its network partner(s) would be similarly motivated to take the actions necessary to make compatible mobile devices commercially available as soon as possible.

III. NEXTNAV IS ACTIVELY ENGAGED IN DISCUSSIONS WITH OTHER STAKEHOLDERS IN THE BAND.

After filing its Petition for rulemaking, NextNav contacted more than three dozen organizations or their counsel—including incumbent tolling entities, railroads, unlicensed users, and amateurs. NextNav informed them about its proposal and encouraged them to participate in this proceeding. NextNav also provided technical details about its proposed network and sought engineer-to-engineer dialogue.

Discussions typically included a review of NextNav's proposed network architecture. Consistent with other bands available for 5G deployment, NextNav has proposed that the new Lower 900 MHz Band be "flexible use" and has proposed adding fixed and mobile allocations to the 902-928 MHz band in the Non-Federal Table of Allocations. Within the reconfigured band, the 900 MHz 5G/TPNT network would be deployed as any other 5G network would and could

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[45] Sascha Segan, *T-Mobile's New 600MHz Band 71: What You Need to Know*, PCMag (Sept. 28, 2017), https://www.pcmag.com/news/t-mobiles-new-600mhz-band-71-what-you-need-to-know.

[46] TR 36.755, 3GPP Technical Report, Annex A; *see also* Monica Alleven, *T-Mobile's 600 MHz Fast Track Enabled By 3GPP-Approved Specs and Work With Broadcast Industry*, Fierce Network (June 22, 2017), https://www.fierce-network.com/wireless/t-mobile-s-600-mhz-fast-track-enabled-by-3gpp-approved-specs-work-broadcast-industry.

include the following types of elements to support both TPNT and 5G: base stations, reliable timing sources, fixed barometric sensor stations, and devices. Base stations would send and receive 5G traffic to/from devices. Base stations would also broadcast PRS resource blocks (which will look identical to 5G network traffic) to devices and will periodically receive measurements from barometric sensor stations. Once operational, NextNav has explained that its state-of-the-art 3GPP-standardized implementation of its licensed spectrum would deliver enhanced PNT accuracy to end users and make additional broadband internet access spectrum available for deployment in the United States. As a follow-up to NextNav's outreach efforts, multiple discussions remain underway and continue to generate helpful feedback that will inform coexistence efforts.

A. NextNav Is Engaging Federal Incumbents.

Federal incumbents have always shared the Lower 900 MHz Band with commercial operations, and federal and non-federal uses have coexisted in the band for more than two decades. To better understand the scope of incumbent federal uses, NextNav retained a consulting firm, HII Mission Technologies ("HII"), with the necessary security clearances to engage with all key federal stakeholders and determine what, if any, technical restrictions might be necessary to protect federal incumbents in the band. While considerable outreach remains to be done, it appears that federal incumbents have a small footprint in the band, mostly confined to a handful of military bases.[47]

[47] NTIA, *902-928 MHz* (Dec. 1, 2015), https://www.ntia.gov/files/ntia/publications/compendium/0902.00-0928.00_01DEC15.pdf.

B. NextNav Is Actively Investigating What Will Need to Be Done to Avoid Interference with Non-M-LMS Incumbents.

Discussions between NextNav and non-M-LMS incumbents are ongoing. While incumbent operations vary, there are, broadly speaking, two primary types of non-M-LMS incumbents in the Lower 900 MHz Band. First, entities such as E-ZPass use the Lower 900 MHz Band to obtain tolling data as cars drive under tolling gantries or through toll booths, or to obtain weight, axle spacing, and other data from trucks at weigh stations. Second, freight railroads use the Lower 900 MHz Band to track cars and equipment trackside throughout their network, at railyards and intermodal terminals.

Tolling and Vehicle Identification. There are two types of toll-collection and vehicle-identification systems in use in the U.S.: ASTMv6 and non-ASTMv6. ASTMv6 systems use active transponders in large commercial vehicles, cover a large communications area (up to 150 feet across multiple lanes), and are used in applications such as truck weigh stations. Non-ASTMv6 systems use active or passive transponders, have a small communications area (12 feet by 12 feet), and are used in the U.S. for tolling, parking garage access, and facility access, etc. Active tags have a battery, and the tag will transmit to the reader after the reader "wakes up" the tag. Passive tags merely reflect backscatter energy. Active tags use fixed, dedicated frequencies—for example, in the TDM active tag protocol, the reader transmits on 915.75 MHz and tags respond between 914.3 to 915.5 MHz. However, many tags in the U.S. are passive and passive tags use different frequencies to mitigate self-interference. That is, a multi-lane tolling station supporting a passive tag protocol could use different frequencies for each lane. NextNav has met with the largest collection of tolling entities in the United States, the E-ZPass Group, and the International Bridge, Tunnel and Turnpike Association (IBTTA) attended those discussions. NextNav and the tolling entities are having engineer-to-engineer meetings to exchange information regarding operating parameters and to work toward a potential joint test plan. The test plan is intended to examine what happens when a 5G system is operating in the same spectrum band as specific technologies used by the tolling entities.

Freight railroads. Freight railroads have deployed RFID tags on stock cars and equipment to support their Automatic Equipment Identification ("AEI") system, which consists of about 6,000 trackside readers nationwide that help them track the location of each rail car and its cargo. In addition, the railroad AEI network plays an integral role in real-time tracking, maintenance, and critical safety systems, ensuring safe and efficient rail traffic transport. Most railroad readers are believed to be tuned to a frequency between 910 and 921.5 MHz, although some may use channels in the 902 to 904 MHz band. The rail industry also uses low-power, unlicensed handheld AEI readers to scan equipment in areas beyond the reach of fixed readers. NextNav continues to work with the Association of American Railroads ("AAR") to better understand the scope of AAR-member operations in the band, and how to account for those AEI readers that operate on frequencies that overlap NextNav's proposed band. To better understand the impact of any potential transition, NextNav is working with MxV, AAR's engineering, research and testing facility in Pueblo, Colorado, to explore the possibility of joint testing.

NextNav has proposed rules consistent with the rules for other sub-1 GHz bands, such as 600 MHz, 700 MHz and 850 MHz.[48] The proposal presents new opportunities and challenges for LMS incumbents. As one example, the conducted Out-Of-Band Emissions ("OOBE") limit NextNav proposed to use, 43+10log(P), is stricter than—that is, more favorable to adjacent services—the current mask in the first ~6 MHz outside the band edge, as shown in the figure

[48] The current OOBE limits for wideband multilateration transmitters specified in 90.210(k)(1) are more lenient than the OOBE limits specified for LMS in 90.210(k)(3) (Other transmitters).

below. Beyond roughly six megahertz, the proposed OOBE limit is less strict. The proposed configuration differs from the status quo but is not uniformly "bad" or "good" for incumbent systems. NextNav continues to talk to stakeholders to understand potential interference concerns.

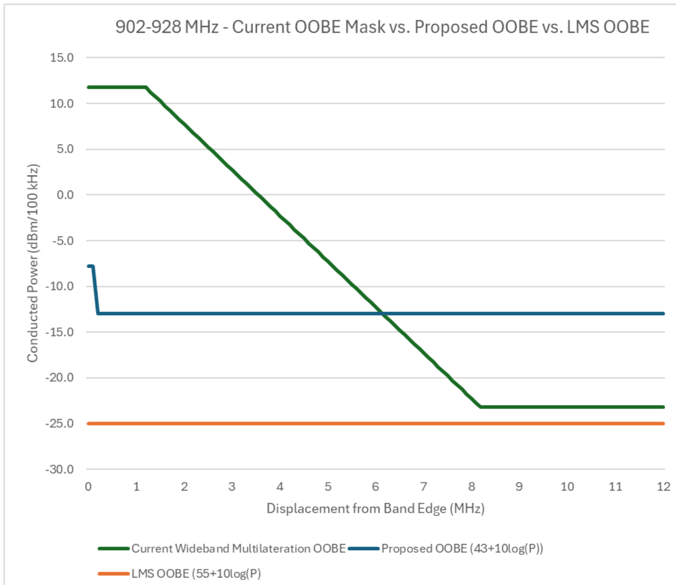

Figure 1 Example of OOBE limit proposed by NextNav

For all types of licensed non-M-LMS systems, NextNav is committed to working with incumbent operators to develop coexistence solutions. To the extent that coexistence requires retuning and other equipment-related costs, NextNav is committed to accommodations, including financial and technical support, that contribute to a smooth transition to a new band plan that allows for more efficient spectrum utilization of the Lower 900 MHz Band.

C. Fact-Finding Continues with Unlicensed and Amateur Operators.

Unlicensed users will continue to operate in the Lower 900 MHz Band. Discussions between NextNav and makers of Part 15 devices are underway. NextNav is aware that there are a variety of unlicensed users in the Lower 900 MHz Band, including radiofrequency ID ("RFID") systems, point-to-point ("PTP") systems, internet of things ("IoT") equipment such as smart meter readers and home security systems, and more.[49] NextNav expects that these uses can continue to operate in the Lower 900 MHz Band, although there will not be a one-size-fits-all solution. For example, LoRa devices operate in the Lower 900 MHz Band. LoRa is not a monolithic standard but comes in many versions. Solving for one iteration will not necessarily mean solving for all versions, but LoRa is a flexible standard designed for unlicensed operations in a heavily encumbered band. NextNav is engaging with leading vendors and plans to operate with a robust array of continued unlicensed use in the band, although the unlicensed users will need to operate alongside licensees, as is the case today.

Additionally, NextNav would like to acknowledge the comments filed in this proceeding by the amateur radio and RFID communities. NextNav has initiated discussions with the American Radio Relay League (ARRL) on the uses amateurs have found 900 MHz to be suited for and the technical characteristics of those uses. Amateur radio provides a way for people to communicate worldwide using various communication modes without relying on cellular or satellite networks. The hobby can offer helpful lessons in electronics and frequency management and, in some circumstances, can provide backup communications in an emergency. Meanwhile, RFID vendors use the Lower 900 MHz Band on an unlicensed basis to support functions such as asset tracking that prove helpful in industries as diverse as manufacturing and healthcare.[50]

The Commission does not have to confront a zero-sum game in which the American public either enjoys the benefits of either amateur and unlicensed services, or a TPNT solution to a national security problem with additional spectrum for broadband service. Instead, the services

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[49] *Unlicensed Spectrum and the U.S. Economy: Quantifying the Market Size and Diversity of Unlicensed Devices*, CTA (Jan. 2022), https://shop.cta.tech/collections/research/products/unlicensed-spectrum-and-the-us-economy-quantifying-the-market-size-and-diversity-of-unlicensed-devices.

[50] Comments of HID Global Corporation on the NextNav Petition for Rulemaking, WT Docket No. 24-240 (Sept. 4, 2024), https://www.fcc.gov/ecfs/document/10904910015705/1.

can both operate in the band. Amateur operators move through multiple bands on an opportunistic basis to find the most suitable channels for their operation and could continue to do so under NextNav's proposal. Meanwhile, RFIDs are designed to incorporate a range of interference mitigation strategies, and, indeed, an ostensibly interfering signal can sometimes cause RFID performance *to improve* because the additional noise helps activate passive RFID tags and close otherwise marginal links.[51] The point is not to say that RFID performance improvements will be common or that overcoming challenges will be easy. The point is simply that the interaction of many different kinds of transmitters and receivers and use cases during a time of rapid innovation defies easy generalization and merits further attention in a notice of proposed rulemaking.[52]

Ultimately, the goal of this or any other FCC spectrum proceeding is to put the available spectrum to its highest and best use. While incumbent systems are valuable for their intended purposes, the costs of making changes to these systems likely pales in comparison to the benefits of finally establishing a terrestrial complement and backup to GPS and opening new resources for broadband deployment for consumers and businesses through the United States.

IV. NEXTNAV'S PROPOSED IN-BAND SPECTRUM RECONFIGURATION SERVES THE PUBLIC INTEREST.

As NextNav explained in its Petition, the current M-LMS band plan, which divides the M-LMS spectrum into three blocks that are neither suited for broadband service nor aligned with 3GPP specifications, does not support robust PNT or integration into broadband networks.[53] To further NextNav's network vision, NextNav proposed that the Commission reconfigure the M-

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[51] Michael R. Souryal et al., *Impact of RF Interference between a Passive RFID System and a Frequency Hopping Communications System in the 900 MHz ISM Band*, Info. Tech. Lab'y et al., http://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=904764.

[52] *See* 47 C.F.R. § 1.407.

[53] Petition at 28–30.

LMS band into a 3GPP-compliant 15-megahertz band.[54] As part of this reconfiguration, NextNav proposed that it would return all active licenses and associated applications and Petitions and receive a single, nationwide flexible use license under the new band plan.[55]

In the Public Notice, the FCC seeks comments on the proposed spectrum reconfiguration, the appropriate mechanisms for enabling the proposed use, the conditions and rules the Commission should apply to the new spectrum environment, and any "windfall" concerns. NextNav provides preliminary responses to these questions below and encourages the Commission to further develop the record on these issues by issuing a Notice of Proposed Rulemaking.

A. Realizing the Benefits of the Proposed Reconfiguration Requires Updated Conditions and Requirements.

To unlock the M-LMS band's potential in meeting the nation's urgent need for a widescale terrestrial complement and backup to GPS, the proposed reconfiguration contemplates new use cases under a new licensing framework and a mobile broadband standard. This new paradigm warrants updated conditions and requirements. In the Public Notice, the Commission seeks comments on the relationship of the proposed reconfiguration to NextNav's prospective compliance with the conditions that the Commission has applied to NextNav's current M-LMS licenses.[56] While similar conditions—such as buildout requirements and deadlines—are likely warranted for the reconfigured band, continued application of the existing conditions would undermine the goal of encouraging investment and innovation by spectrum licensees. NextNav requests that the Commission propose in the Notice of Proposed Rulemaking to remove legacy

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[54] *Id.* at 28.

[55] *Id.* at 29–30.

[56] Public Notice at 5. These licenses are held by NextNav's subsidiary, Progeny LMS, LLC.

conditions under the new 15-megahertz license and seek comments on appropriate conditions and requirements to impose on the new license.

For example, the Commission required NextNav to provide location accuracy services on all of its B and C Block licenses until April 3, 2028, and prohibited NextNav from assigning, transferring, partitioning, disaggregating, and/or leasing these licenses to any third party.[57] The restriction on transfer, partition, disaggregation, or lease until April 3, 2028, is incompatible with NextNav's vision for the new 15-megahertz band, under which NextNav plans to make at least 95% of the downlink spectrum resource blocks available for 5G broadband through partnerships with broadband providers. While NextNav is open to a variety of mechanisms for these partnerships, NextNav expects that spectrum leasing would be an effective way of realizing its network vision. Applying the current restriction on leasing to the new 15-megahertz license would preclude this type of partnership until at least 2028 and unnecessarily delay full utilization of the reconfigured band, including the urgent need for a terrestrial complement and backup to GPS.

NextNav supports the Commission in seeking comments in response to a Notice of Proposed Rulemaking regarding the appropriate conditions and requirements for the reconfigured band, including any performance requirements, and regulations or license conditions to ensure that a widescale TPNT system that serves as a backup and complement to GPS is permanently implemented and maintained.

[57] *See In re Request of Progeny LMS, LLC for Waiver and Limited Extension of Time*, Order, 32 FCC Rcd 122, 137-38 ¶¶ 32-33 (WTB 2017), *extension of time granted by* 35 FCC Rcd 7136 (2020); *In re Progeny LMS, LLC Request for Waiver and Extension of Time, Further Request for Waiver and Extension of Time, Further Waiver Request, Request for Waiver and Extension of Time*, Order, 38 FCC Rcd 2342, 2357 ¶ 34 (WTB 2023).

B. The Proposed Reconfiguration Will Not Result in a Windfall to NextNav.

The Commission seeks comment on "NextNav's proposal to receive more spectrum in a larger geographic area than currently held," and whether the fact that NextNav's A Block licenses—which NextNav has proposed to turn in as part of the reconfiguration—were terminated and never authorized for commercial operations, should have any effect on the requested rebanding.[58] It also seeks comment on any windfall that NextNav might receive as a result of its proposal.[59]

The proposed reconfiguration puts M-LMS spectrum, including spectrum sitting fallow in the FCC inventory, to higher and better use, and offers significant public interest benefits in the areas of national security, public safety, and consumer access. Realizing these benefits, however, requires a single licensee that is committed to a 5G network vision and willing to bear the considerable costs associated with creating a reliable and precise TPNT complement and backup to GPS. NextNav also expects to provide appropriate financial and technical support to site-based licensees in the band. This arrangement does not result in a windfall to NextNav, but at this time the full costs to NextNav are unknown and the benefits have not yet been quantified. NextNav looks forward to providing further information on these issues as the rulemaking progresses.

CONCLUSION

Change is a part of progress. While change can prove unsettling, it drives the types of innovations that the United States needs to remain a global technical leader. Moving from a Petition for rulemaking to a Notice of Proposed Rulemaking does not require the Commission to

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[58] Public Notice at 5.

[59] *See id.* at 6.

have all, or even most, of the answers, but simply to have found information in the record sufficient to support a conclusion that questions the Petitioner raises are worth asking in the first instance.

In this case, few challenges are more pressing than incorporating greater resiliency into lifesaving PNT technologies and identifying more spectrum to make wireless broadband services more accessible and useful for consumers. In its Petition, NextNav provided a detailed, economically principled, and technically feasible mechanism means to start addressing these important national priorities by making better use of the primary licensed spectrum that NextNav acquired at auction or on the secondary market. NextNav appreciates the Commission's consideration of how to rationalize the Lower 900 MHz Band to allow for next-generation broadband deployment and a much-needed TPNT backup and complement to GPS. NextNav looks forward to engaging with all stakeholders about its proposal to put the Lower 900 MHz Band to its highest and best use.

Respectfully submitted,

/s/ Robert Lantz

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September 5, 2024

Appendix A

Resilient Positioning, Navigation, and Timing for Public Safety

NextNav Inc.

September 5, 2024

Table of Contents

Executive Summary

The Global Positioning System (GPS) is a cornerstone of the nation's Positioning, Navigation, and Timing (PNT) infrastructure,[1] yet it faces significant limitations, especially in indoor environments where many emergencies occur. There are challenges faced with current technologies used in public safety and emergency services, and there is a broad consensus from the public safety community that there is a need for improved location accuracy. Further, public safety is heavily reliant on GPS technology for effective operations—and there is currently no backup in place. NextNav's NextGen terrestrial 3D PNT technology can play an important role in addressing some of these challenges that exist within the public safety community.

Background and Importance of PNT in Emergency Services

GPS is widely used in public safety for determining the location of 911 callers and maintaining situational awareness for first responders. However, the expectation that emergency services can pinpoint the precise location of a 911 caller is often unmet, particularly when the call originates from indoor locations where GPS signals are weak or obstructed. The inability to accurately track caller locations has been a longstanding issue, with significant implications for emergency response efficiency and effectiveness despite recent improvements made.

Current Challenges in Public Safety PNT

The document outlines several challenges associated with the current use of PNT services in public safety:

- **Indoor Limitations**: GPS signals struggle to penetrate buildings, leading to inaccuracies in caller location data.
- **Urban Environments**: Dense urban areas, with their "urban canyons," further complicate accurate location tracking due to signal reflections and obstructions.
- **Technological Gaps**: Existing technologies, while improved over the years, still fail to provide reliable location data under various conditions, necessitating the use of complementary PNT solutions.

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[1] The Federal Communications Commission ("FCC") has granted a waiver to permit non-Federal receive-only earth stations to operate with the Galileo system to support E911 operations. *See In re Waiver of Part 25 Licensing Requirements for Receive-Only Earth Stations Operating with the Galileo Radionavigation-Satellite Service*, Order, 33 FCC Rcd 11322, 11346-47 ¶ 53 (2018).

NextNav's NextGen 3D PNT Solution

NextNav proposes a terrestrial-based 3D PNT solution designed to complement and, when necessary, provide a backup to GPS. This solution addresses the limitations of current GPS-based systems by offering:

- **Improved Accuracy**: Sub 10m horizontal accuracy and vertical accuracy within 3 meters, even in challenging environments.
- **Indoor and Urban Utility**: Effective performance in indoor settings and urban areas where GPS signals have limitations.
- **Backup Capabilities**: In case of GPS signal disruptions, ensuring continuity in emergency services' ability to locate and respond to incidents.

Benefits for Public Safety

The adoption of NextNav's terrestrial 3D PNT technology promises several benefits for public safety:

- **Reduced Response Time**: More accurate location data allows for quicker dispatch of first responders, potentially saving lives.
- **Improved Situational Awareness**: First responders and incident commanders can better visualize the incident scene, enhancing coordination and decision-making.
- **Enhanced Reliability**: A terrestrial PNT system serves as a reliable backup, ensuring continuous operation even during GPS outages.

The integration of advanced PNT solutions like NextNav's 3D PNT technology is crucial for overcoming the limitations of current GPS systems in public safety. By providing highly accurate and reliable location data, this technology can significantly improve emergency response times and overall situational awareness, ultimately enhancing the effectiveness of public safety operations.

Introduction and Background of PNT and Emergency Services: 911 Callers and Situational Awareness for First Responders

How PNT Is Used for Emergency Services

This section explains how extensively PNT is used for 9-1-1 caller location and situational awareness for first responders. Accurate location data is essential for determining the location of a 9-1-1 caller and dispatching first responders efficiently to save lives. Public safety dispatchers emphasize the critical need for improved location accuracy of wireless devices, as poor location data can lead to delays and errors in emergency response. GPS and complementary PNT technologies are vital to improve emergency response effectiveness especially in urban and indoor environments.

911 Callers

GPS plays a pivotal role in the nation's PNT architecture, and is a key technology currently used by public safety. Yet, GPS does not work well indoors, and emergencies frequently happen indoors. With improvements in technology, our society has expectations around our devices to detect an accurate location. As a result, there is an expectation among Americans that if they place an emergency 911 call on their cell phone, their accurate location can be provided to operators and first responders. Having an accurate location is of the utmost importance in effectively dispatching first responders to an emergency and saving lives.

As shared in the National Institute of Standards and Technology (NIST) Internal Report (IR) 8443 Voices of First Responders: How to Facilitate Adoption and Usage of Communication Technology:

"They think that if they call 911 we know where they are and we don't."[2]

"Location is number one. We can dispatch. We can do anything else in the world with that call if we have the location. But getting that location is just paramount. We can't do anything if we don't get a location."[3]

"The biggest improvement that all 9-1-1 public safety dispatchers would like to see is the location accuracy of wireless cell phone devices....It is literally costing lives whenever a dispatcher cannot locate a caller who is calling in from a wireless device and the location accuracy is poor or non-existent. Wireless calls account for over 80% of our inbound emergency calls."[4]

"Okay so let's say I'll use a domestic because a domestic I think is a pretty good example of a regular call that we take so **the most important question that we ask always is the first question we ask is what is the location. We need to know where it is right? Our technology in terms of locating people is just not there.** We don't know where you are you know I've used the map as a reference but based off of the cell tower that you're hitting

[2] Yee-Yin Choong et al., Nat'l Inst. of Standards & Tech., U.S. Dep't of Commerce, NISTIR 8443, *Voices of First Responders: How to Facilitate Adoption and Usage of Communication Technology, An Integrated Analysis of Qualitative and Quantitative Findings*, 20 (Nov. 2022), https://nvlpubs.nist.gov/nistpubs/ir/2022/NIST.IR.8443.pdf ("NISTIR 8443").
[3] *Id*.
[4] *Id*.

off of I don't know where you are. You could be anywhere you know and that's why we get a lot of calls for different jurisdictions."[5]

However, according to the NIST study, "current technology, especially cell phone and texting technology, makes accessing caller location difficult."[6] Specifically, 87.89% of Communications and 911 responders in the NIST study cited the "inability to accurately track caller location" always, most of the time, or some of the time.[7]

Obtaining caller information can be challenging—it could be a person who is unable to speak due to a medical emergency, a child who doesn't know their address, or an elderly person with dementia who cannot remember where they are. Although the 911 operator may be asking to confirm a location, it is often challenging to be able to get accurate location with a verbal confirmation from a caller. According to the NIST study, "Across the board, COMMS participants indicated that location is the most important piece of information to obtain. Yet…it is sometimes difficult to elicit. Callers do not always know where they are: the street address, the cross street, or the name of the business or location. Other times, callers hang up without providing the location or they provided an incorrect location. The inability to obtain accurate caller (incident) location creates emotional stress for COMMS workers who understand that first responders in the field are relying on them for accurate location data."[8]

According to NENA, approximately 80% of emergency calls are made from wireless devices,[9] and as the FCC has previously stated, there is a strong "likelihood that wireless 911 calls will come from indoor environments where traditional location accuracy technologies optimized for outdoor calling often do not work effectively or at all… [T]he

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[5] NIST, *PSCR Usability Results Tool - Interview Quotes*, 501, 1501, 1570-71, 1719, 2179, 2984, https://publicsafety.nist.gov/interviews.html (last visited Aug. 29, 2024) ("NIST Survey Interview Quotes").
[6] NISTIR 8443 at 20.
[7] Shanée Dawkins et al., Nat'l Inst. of Standards & Tech., U.S. Dep't of Commerce, NISTIR 8400, *Voices of First Responders—Nationwide Public Safety Communication Survey Findings: Day-to-Day Technology, Phase 2, Volume 3*, 27 (Oct. 2021), https://nvlpubs.nist.gov/nistpubs/ir/2021/NIST.IR.8400.pdf.
[8] Michelle Steves et al., Nat'l Inst. of Standards & Tech., U.S. Dep't of Commerce, NISTIR 8295, *Voices of First Responders – Examining Public Safety Communication from the Perspective of 9-1-1 Call Takers and Dispatchers, Findings from User-Centered Interviews, Phase 1, Volume 4*, 24 (Mar. 2020) ("NISTIR 8295").
[9] NENA: The 911 Association, *9-1-1 Statistics*, https://www.nena.org/page/911Statistics (last visited Aug. 19, 2024).

public rightfully expects 911 location technologies to work effectively regardless of whether a 911 call originates indoors or outdoors."[10]

According to the United States Environmental Protection Agency (US EPA) sponsored National Human Activity Pattern Study (NHAPS), people spend approximately 87% of their time in indoor environments—including residential buildings, office buildings, restaurants, and other indoor places, such as malls, stores, schools, public buildings, parking garages, etc.[11] Providing an accurate location is even more complex in multi-story buildings with a 3rd dimension, where the importance of z-axis (vertical location) is also necessary. NextNav's own internal data of 911 calls that have passed through its system in its coverage areas suggests that approximately 40% of emergency calls are coming from the second floor of a building or above.

"[R]ight now, we pull up and we have no idea, so there's a lot of wasted time. Wasted not being the correct word, but [**it] truly is wasted if we search-- if it's a three-story building and everybody's unconscious on the third floor, and we spend the first ten minutes on one and two looking for them, those minutes were critical to their survival rate.** So if we could go right to three, that would change things. So if we had smart buildings in the future, that would be awesome."[12]

Situational Awareness for First Responders

Further, it is important to be able to not only know the location of emergency callers to be able to dispatch help in a timely manner, but accurate location is important to provide better situational awareness for first responders and ensure that their own lives can be saved if they are in a dangerous situation, with a need to ensure that their communication and accurate location can work well indoors. More and more devices with integrated GPS receivers have become available for first responders, enabling the real-time tracking of personnel, vehicles, and other assets. However, access to accurate GPS signals for positioning can be limited in many situations as described above for example, in a densely populated city with skyscrapers that are close together, without accurate x/y location and z-axis information, first responders could mistakenly go into the wrong building or the wrong floor during an emergency.

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[10] *In re Wireless E911 Location Accuracy Requirements*, Fourth Report and Order, 30 FCC Rcd 1259, 1260 ¶ 2 (2015) ("*FCC E911 Fourth Report and Order*").

[11] Mehzabeen Mannan & Sami G. Al-Ghamdi, *Indoor Air Quality in Buildings: A Comprehensive Review on the Factors Influencing Air Pollution in Residential and Commercial Structure*, 18 Int'l J. Env't Rsch. Pub. Health 3276 (2021), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8004912/.

[12] NIST Survey Interview Quotes at 2232, 4195.

According to a Public Safety Communications Research (PSCR), a Division of NIST and Indiana University, study, "Tracking and situational awareness has long been a problem for first responders. While GPS tracking can roughly establish where on earth a person is, it is often not accurate enough to ascertain a person's location [inside] or elevation within a building. Knowing the exact location of first responders within a structure is vital to their safety during a search and rescue operation."[13]

As shared in the NIST report regarding first responder desired technologies:

"Better tracking of the deputies, fire fighters, and the public is paramount!!"[14]

"Wherever I am, they can know that Lieutenant [Name] is right there. **If I fall through a floor, next thing they know is that I'm on floor 22.** The ability to maybe be able to track people with individual GPSs in our backpacks, in our radios, something like that. So at any given point that the command post, like you see in the movies with everyone standing around the big 3D, 3-dimensional, and you could see where all your units are, all your people."[15]

"A fireman gets hurt and killed or get lost and I'm lost in a big building and I say, **"Come help me, come find me." And they say, "Where are you?" And I say, "I have no idea."** Why can't they find me off this thing? If it was my cell phone, you could find me. Okay. So if I'm starting to have collapse, then I have to worry about bringing people out. I have to protect my people now. And I'm going to get them to areas where they're not going to get caught in a collapse. And that's not just the building, that's around the building because the building is going to fall over."[16]

"I would say there have been a lot of issues with high rises just because of all the interference, frequency interference in downtown, for sure. And I would say that's probably the biggest communication issue, especially when you're on fire ground. Sometimes our fire ground frequency only goes so far. It's not a very strong signal. **And so if you're 25 floors up or 40 floors up and you're trying to talk to someone on the ground floor, it may not go through as well.** So there's times where even other departments, they'll put almost repeaters that are on different floors that transmit and repeat their message. Or there's repeaters built in the high rise."[17]

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[13] First Responder Smart Tracking Challenge, *Come with Us to the Cutting Edge*, https://frstchallenge.com/ (last visited Aug. 19, 2024).
[14] NISTIR 8443 at 20.
[15] NIST Survey Interview Quotes at 369-70, 3490.
[16] *Id*. at 1204.
[17] *Id*. at 334-35, 1939-40, 3070-71.

PNT Uses in Public Safety and Challenges Today

Public safety uses location information to know where to deliver assistance exactly where it is urgently needed, and to help first responders maintain situational awareness. For this reason, there is a critical need for reliable and accurate PNT services in public safety for 9-1-1 caller location, First Responder situational awareness, radio communication, and First Responder applications.

Several years ago, when landlines were the dominant means of communicating during an emergency, correlating an address to the calling party number was relatively easy; a landline has a specific address associated with the number. A wireless call, however, delivers location coordinates which, depending on where the device is, can be accurate, somewhat accurate or widely inaccurate—and as a result, requires Public Safety Answering Point (PSAP) telecommunicators to extract this information from callers by asking, "WHERE is your emergency?" or a similar question. As such, being able to deliver consistent location accuracy is challenging and requires alternative PNT services at scale.

When wireless calls quickly overtook wireline calls in terms of % of all 9-1-1 calls made, the Commission adopted comprehensive rules and deadlines for improving E9-1-1 wireless location accuracy. The goal is to achieve what is referred to as "Dispatchable [L]ocation," which consists of "the validated street address of the calling party, plus additional information such as suite, apartment or similar information necessary to adequately identify the location of the calling party."[18] In order to achieve this milestone, there have been significant actions taken by the Commission to deliver the level of caller location intelligence needed. A major step forward towards achieving Dispatchable Location was made in 2015 by the Commission, which today requires nationwide commercial mobile radio service (CMRS) providers to provide an x/y-axis horizontal (or 2D) location that is within 50 meters of accuracy for 80% of all wireless E9-1-1 calls.[19] In urban areas and specifically indoors, a 50-meter uncertainty from the street centerline could mean that the X/Y location will be 50 meters in either direction, resulting in an uncertainty that can place a caller's location in the wrong building. This x/y uncertainty is limited further when a caller is indoors, as GPS signal strength may not effectively penetrate buildings, requiring the telecommunicator to verbally query the 9-1-1 caller to identify more granular details, including which floor and/or unit number they are in.

As time to respond is of the utmost importance to public safety, location accuracy is critically important, and as the dynamics of the response process differ based on geography, how location information is delivered to the PSAP. For those in rural or suburban

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[18] 47 C.F.R. § 9.3; *see also id.* § 9.10(i)(1).
[19] *FCC E911 Fourth Report and Order*, 30 FCC Rcd at 1261 ¶ 6.

areas that are less prone to signal degradation or interference, Phase II wireless (x/y location and accuracy confidence) can work for many.[20] While 9-1-1 calls and first responders both rely on GPS, in urban areas, additional technologies are leveraged to account for PNT performance limitations; capabilities, including Device Based Hybrid (DBH) services on Android and iOS devices, Wi-Fi access points, in-building Distributed Antenna Systems (DAS) help to reduce the x/y uncertainty of 9-1-1 calls. These options are useful but also have limitations as described herein.

PNT services for public safety in urban areas must leverage, where available, these additional technologies due to urban canyons and resulting multipath errors exacerbated by building materials and signal degradation.[21] As urban areas pose the greatest challenges, buildings with thick concrete or which are constructed of metal pose further limitations to GPS signals and corresponding multipath errors, amplifying the need for PNT alternatives that can work indoors in urban environments. Whereas callers are impacted by geography and routing technologies available, the technology providing the location itself must be modernized to accommodate all device types, not solely based on operating systems or proprietary methods. Conversely, just as it is critical for 9-1-1 callers to be served in the quickest and most appropriate fashion possible, First Responder location and situational awareness by command can mean the difference between life and death.

9-1-1 Call Location Information at the PSAP: Delivery, Processing and PNT Services

When a call to 9-1-1 is made from a mobile phone, carriers deliver the call based on the x and y (2D) location associated with the device. The GPS receiver in the phone is used to associate the devices x/y location by triangulating its signal off of three (3) satellite position fixes (known as trilateration). This process allows for the device itself to be located within this area at a specific radius or cone of certainty. In a rural area with no major terrain undulations, buildings or heavy tree cover, use of GPS-derived x/y location can be suitable for locating the emergency caller.

However, in urban areas, signal interference can be much more prominent, whereby triangulation of the signal is not viable due to buildings and line-of-sight challenges. This is also highlighted on GPS.gov: “GPS-enabled smartphones are typically accurate to within a 4.9 m (16 ft.) radius under open sky. However, their accuracy worsens near buildings,

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[20] NENA: The 911 Association, *Cell Phones and 9-1-1*, https://www.nena.org/page/911Cellphones (last visited Aug. 19, 2024).

[21] *See* Ahmed S. Mohamed, Mohamed I. Doma, & Mostafa M. Rabah, *Study the Effect of Surrounding Surface Material Types on the Multipath of GPS Signal and Its Impact on the Accuracy of Positioning Determination*, 8 Am. J. Geographic Info. Sys. 199 (2019), https://bit.ly/3YMgOj6.

bridges, and trees" and "[m]any things can degrade GPS positioning accuracy[,]" including "[s]atellite signal blockage due to buildings, bridges, trees, etc.[,] [i]ndoor or underground use[,] [and] [s]ignals reflected off of buildings or walls ([referred to as signal] 'multipath')."[22]

As noted earlier, DBH capabilities—which is a position estimation method utilizing a selection or combination of location methods in a handset, including GPS, Wi-Fi, and other sensors—can assist in overcoming the greater uncertainty of the x/y (2D) location.[23] However, this method is only effective for specific mobile device types. This challenge can impact populations that have been historically underserved, as these demographics are more likely to use devices which do not support DBH. Further, the lack of in-building Wi-Fi access can further make this method a challenge.[24]

Equitable location for all callers is crucial and, while the technologies exist today to assist in closing this gap, there is not yet a standard way of accessing, processing, and delivering precise location from any 9-1-1 caller device. Additionally, Wi-Fi doesn't have the same quality of service as GPS and is not wide scale or consistent enough to serve as a GPS backup for location services.

Upon delivery to the PSAP, the location associated with the call is delivered in textual format as part of the Automation Location Information string and also plotted on the map used by the PSAP telecommunicators. When the 9-1-1 call is plotted on the map, typically a cone of uncertainty is displayed, providing for the telecommunicator a radius of probability as to where the actual device (and caller) are located. When a call is presented to the Call Handling Equipment, often referred to as the "Call Handling system"), the telecommunicator must verify that the location of the call as presented is in fact correct; through a verbal confirmation process, the caller is queried to either verify the location or assist in determining it through landmarks and/or street names.

As stated in the NIST study, "The most important task is acquiring accurate information from the caller. Again, COMMS workers know how much is on the line based on their ability to obtain all the information necessary for incident response. Given that a timely and effective emergency response relies on the call taker obtaining the necessary information,

[22] *See* U.S. Space Force, *GPS Accuracy* (last modified Mar. 3, 2022), https://www.gps.gov/systems/gps/performance/accuracy/.

[23] *See* CTIA, *A Decade of Technology Improvements in 9-1-1 Location Accuracy Helps First Responders Save Lives* (Apr. 16, 2024), https://www.ctia.org/news/a-decade-of-technology-improvements-in-9-1-1-location-accuracy-helps-first-responders-save-lives.

[24] Bipartisan Policy Center, *Understanding the Urban Digital Divide* (Mar. 5, 2021), https://bipartisanpolicy.org/blog/urban-broadband-blog/.

the struggle to acquire the information only adds to the pressure and perceptions of lack of control, and stress."[25]

This process consumes precious seconds (or even minutes), time that is critical to the efficacy of the response, made even more challenging when the 9-1-1 caller is panicked or in an unfamiliar area. Due to location uncertainty in certain environments such as urban areas, indoors or below ground, the telecommunicator must extract as much information about the location as possible before first responders can be dispatched; before the dispatch sequence can commence, a physical address must be determined which directs the responder to the correct street address based on the caller's location. As true Dispatchable Location is one which accounts for the physical address, floor level/number and unit/suite number of the location, telecommunicators require further location intelligence to process 9-1-1 calls from above the ground (vertical location, or the z-axis).

In order to progress towards a Dispatchable Location end-state, the Commission in 2015 adopted comprehensive rules and deadlines for improving E9-1-1 wireless location accuracy to include vertical location, or the z-axis.[26]

To reduce time to dispatch, particularly in urban and multi-story environments, this ruling by the Commission was a critical step as knowing the street address is crucial but having 3D (x/y and z) location is paramount to getting closer to achieving the Dispatchable Location goal for wireless calls. While +/- 3 meters in the z-axis assures location accuracy is within one floor (either direction), this information is crucial as it will dramatically impact service delivery in urban areas where population density is highest.

By adding the z-axis, PSAPs gain important vertical location data, reducing time to respond in multi-story buildings. However, as recently highlighted by APCO in their ex-parte filing, "Few 9-1-1 emergency communications centers (ECCs) have the resources to even explore how to make use of HAE-based vertical information (assuming this information is indeed accurate)."[27] As a result, PSAPs today are just now beginning to use z-axis as it is delivered via Height Above Ellipsoid (HAE) but must employ translation tools to make this location coordinate "actionable" (i.e., PSAPs require a vertical measurement in Height Above Terrain (HAT)). Whereas z-axis location data is highly important, having a means to use this data is critical; PSAPs today are just now beginning to operationalize the use of z-axis data, employing translation tools to make this location coordinate "actionable." While HAE is the means for carriers to deliver the z-axis value to the PSAP, this format is not in a usable state

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[25] NISTIR 8295 at 25.
[26] *See FCC E911 Fourth Report and Order*, 30 FCC Rcd at 1261 ¶ 6.
[27] Letter from Jeffrey S. Cohen, Chief Counsel, APCO International, to Marlene Dortch, Secretary, FCC, GN Docket No. 17-183, ET Docket No. 18-295, PS Docket Nos. 07-114 and 15-80, ET Docket No. 04-35, 2 (Jan. 31, 2024), https://bit.ly/3ArmBAo.

as HAE is based on a formula for the curvature of the earth rather than location from the ground level. With location that is delivered in HAT (also referred to as “Height Above Ground”), PSAPs are able to begin using 3D PNT services which benefit both the 9-1-1 Call Handling/Processing operations as well as Dispatch Operations. To achieve an accurate HAT value, an accurate x/y coordinate is instrumental to account for terrain changes. This is a specific challenge in urban environments where there are slopes and/or hills, as ground variation will impact the HAT value; a precise x/y coordinate that is under 10 meters will improve the accuracy of the HAT value, progress towards attaining the goal of Dispatchable Location. Urban environments are where population density and indoor environments are most prevalent and therefore, a more accurate x/y is paramount to reduce time-to-caller indoors and specifically at elevation.

9-1-1 PSAP / Dispatch and PNT

Upon gathering the 9-1-1 caller’s location and necessary details (such as type of emergency), the dispatch process is being prepared. Depending on the types of Call Handling and Computer Aided Dispatch (CAD) systems that are in the PSAP and operational criteria, the information captured is entered into the CAD system either by the telecommunicator or dispatcher. Whereas the telecommunicator is focused on engaging with the public, the dispatcher communicates with the respective first responders, and the information and software that is used to manage the response itself is the CAD system. CAD systems are data management platforms used to manage the vast amounts of information associated with any response, consisting of interfaces and/or integrations with many sub-systems, data sources, and feeds.

With respect to the location coordinates, CAD systems currently work based on a 2D map environment (as do most 9-1-1 Call Handling systems) and when possible, CAD vendors can leverage tools to capture, translate, and visualize 3D positioning data in a 3D view. Leveraging z-axis location data is critical for dispatchers and responders, and having the 3D contextual view is a must-have for public safety delivered ubiquitously from the device to the PSAP and vice-versa. Without an accurate x/y coordinate in the appropriate building footprint, agencies are not able to leverage the value of z-axis at scale. A nationwide x/y location service that delivers single-digit accuracy at scale would overcome this limitation and allow agencies to move to a 3D visualization experience via CAD.

As the telecommunicator and/or dispatcher enters or receives the 9-1-1 call data in the CAD, the dispatcher will assign the appropriate response based on the information gathered, as well as any history in the system for that caller, initiating the dispatch to the location. Without an accurate location determined, the time to dispatch can increase which can place those experiencing a severe emergency even further at risk; in the public safety industry, seconds count, so when a location is not known or is incorrectly gathered (i.e., misheard or misstated), it truly will impact the efficacy of the response. Location needs to be accurate, scalable, and delivered in a consistent manner to work seamlessly across the ecosystem. While there are several non-standard, over-the-top capabilities which exist allowing a PSAP telecommunicator or dispatcher to query the location of the device (e.g., through an SMS link or caller location query), the process is another time-consuming step which does not work on all devices. Public safety technology vendors have tried to overcome these types of location-oriented challenges through unique approaches, yet these are only stop-gaps to a larger challenge.

With the location determined for the response and the dispatch sequence initiated, the first responders assigned to the incident will be underway. For those in a vehicle, they receive their information in data format on their in-vehicle Mobile Data Terminal (MDT). The MDT provides not only a map of the route for navigation purposes but, just as critically, the location of the unit itself to command staff as well as traffic management systems for collision avoidance. When dispatch initiates the response process via CAD, the respective incident data is transmitted via cellular service to the vehicle's MDT, a computer or tablet (or in some agencies, a docked cellphone) equipped with a cellular modem and GPS antenna. When x/y location is degraded, response times can potentially increase, and command staff may lose the ability to locate vehicles via Automatic Vehicle Location as these systems are reliant upon GPS for positioning and navigation.

With respect to delivering emergency services, knowing the best path to navigate to the 9-1-1 caller is highly important, yet when signals are degraded and/or a fix cannot be established, the fastest route may not be presented.

As data management is done via the CAD system, voice communications are predominately delivered over the Land Mobile Radio (LMR) system of each jurisdiction. Additionally, many agencies have begun benefiting from mission-critical broadband services like those provided by FirstNet Built with AT&T, Verizon Frontline, and T-Mobile. Whether leveraging the scale and power of FirstNet or using the voice services of an LMR system, audio communications are still predominately separate from data services. Both communication modalities will interface with the CAD system for talk group management but having the ability to ubiquitously deliver 3D location from LMR to broadband remains a challenge.

First Responder and PNT

Once the responder is at the dispatched location, and upon exiting the vehicle, there are two core technologies at work—the LMR service by way of the portable radio and/or a cellular device, either a ruggedized cellphone or a push-to-talk over cellular device. The key capabilities relied upon via either technology are voice communications position (location), emergency/SOS/man down, and group callout. With an LMR system, the responder's portable device will use GPS to provide the location; cellular devices can leverage GPS as well as Wi-Fi, Bluetooth beacons, and DAS among other technologies to deliver the responder's location.

When the emergency is indoors, to locate the emergency caller, the responder will use the information provided on their MDT and, depending on the type of response, either enter the premises or pre-position with other responders prior to entry. If using a cellular device for communications, they may also be able to access the same data as is displayed in the vehicle, providing a map or textual view of the caller's location as delivered. Whether the responder is using an LMR radio or a cellular device (or both), location is derived from GPS and, as such, has the same indoor challenges for location accuracy. In urban areas, as the caller location when indoors is challenged due to current technology limitations, the responder will spend precious time navigating the building, confirming or seeking further information from dispatch which amplifies the stress on the responder, health and safety of the caller and, in some cases, places the responder unknowingly at risk. If the caller location has been spoofed, for example via a "swatting" call, the responder could be walking into an ambush situation. Or, if the caller's location is from a 49-story high-rise apartment complex, their z-axis information will be less useful if the PSAP which handled the call does not have HAE to HAT translation in place, making an already stressful situation worse.

Incident Command, Situational Awareness, and PNT

Just as the caller's location is challenged indoors, obtaining an accurate location fix on the responder is also limited. While the responder is focused on the caller's safety, dispatch is focused on the responder's safety; when the responder needs backup, locating the individual is possible using voice service and verbal instructions. Command needs to know where the responder is during the response, ensuring personnel accountability and situational awareness is preserved. However, when a responder needs help and they either cannot speak, have become disoriented, have fallen through a floor or fallen due to physiological stress, 3D location is critical to life safety and personnel accountability.

Technologies supporting First Responder situational awareness in-building have advanced significantly in recent years, leveraging a combination of hardware and software innovations, including the use of indoor wireless signals/beacons, building models/floorplans, and dedicated apps on smartphones or tablets to provide access to critical information, such as the building layouts, emergency protocols, and real-time updates.

While in-building technologies have significant benefits to enhancing situational awareness and responder communications, relying upon them to provide accurate positioning or contextual location is not scalable as only a small percentage of buildings nationwide currently benefit from these types of systems and are typically leveraged in new construction. Retrofitting all buildings nationwide is not practical as the costs and logistics to do so would outweigh the benefits.

Z-axis Used in Emergency Services for Public Safety

With respect to the vertical plane (z-axis), traditional means of location service are also challenged. While GPS provides accurate x/y location in unobstructed environments, calculating an accurate z-axis measurement that meets the Commission's requirement in urban environments is challenging. As such, the ability to deliver a consistent 3D location necessitates the use of a different methodology or z-axis measurement, that being barometric pressure. As nearly all cellular devices are manufactured with barometric pressure sensors, delivering a z-axis value is a very viable means of determining elevation. The x/y positioning data is based on the device's (radio, mobile phone, etc.) receiver capabilities measured position utilizing GPS and/or indoor wireless signals/beacons if available. The z-axis data is also based on the available measurement capabilities of the device (i.e., GPS, access point/beacon database, barometric pressure sensor). These technologies collectively enhance the effectiveness and safety of first responders by providing them with accurate, real-time information and tools to navigate and respond to emergencies in complex indoor environments. Device GPS and barometric pressure measurements are significant technology advances, but there is still room for improvement. Uncompensated Barometric Pressure (UBP) is a measurement of atmospheric pressure typically captured natively by most smartphones. One concern about delivering and using UBP is that the data is "uncompensated": it does not "compensate" for variations in air pressure.[28] As NENA has explained, for example, local weather conditions affect barometric pressure, meaning that UBM measurements at the same altitude may be quite different on different days and different hours.[29] In another example, within a building, changes may be caused by forced-air heating and air conditioning systems.[30] These changes can make indoor UBP measurements seem to be at a lower altitude than an outdoor measurement at the same level. UBP also does not take

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[28] NENA: The 911-Association, *NENA Requirements for 3D Location Data for E9-1-1 and NG9-1-1*, 53 (2022), https://cdn.ymaws.com/www.nena.org/resource/resmgr/standards/nena-req-003.1-2022_3d_gis_2.pdf.
[29] *Id*.
[30] *Id*.

into account the problem of "drift," or calibration errors that occur as the measuring device ages.[31]

Compensated barometric pressure utilizes a network of surveyed barometric reference stations, to normalize inaccuracies from device barometric measurements (compensating for sensor drift and other environmental factors) allowing for greater precision of z-axis location, ensuring that the ability to locate a caller or responder is within +/- 3 meters greater than 80% of the time. NextNav's Pinnacle z-axis service has been demonstrated in independent testing conducted by the CTIA in 2018 to provide +/- 3 meters accuracy 94% of the time and demonstrated superior performance (compared to other technologies) in urban and dense urban morphologies, where arguably vertical location has greater importance, with more multistory buildings.[32]

Public safety can make use of HAE data by improving the context of the ground elevation reference (x/y location). Public safety can make greater use of HAE data by converting it to HAT. Gaining further HAT accuracy is attainable by delivering a more accurate x/y coordinate, a must-have for dispatchable location to be achieved as the terrain has a direct correlation to the actual device elevation from the ground level.

NextNav NextGen 3D PNT Solution Addresses Public Safety PNT Challenges as a Complement to GPS

Terrestrial PNT systems, such as NextNav's NextGen solution can offer performance characteristics that are complementary to a GPS PNT solution to function where GPS has coverage limitations (e.g., urban canyons and indoors). This hybrid approach enhances overall system performance, especially in scenarios where GPS signals may be temporarily unavailable or degraded. Use of this solution can also help ensure accurate, available x/y-axis and z-axis positioning and timing, even when GPS services are disabled, disrupted, or cannot be received. The following are some of the characteristics of NextNav's NextGen terrestrial 3D PNT solution, able to address many of these challenges.

NextNav's NextGen positioning and timing solution will be a 5G New Radio (NR) based PNT system to determine location and timing of a signal's time of arrival to the receiver and offers a full 3D positioning service which includes a barometric-sensor-based z-axis solution. Additionally, the NextGen solution will make use of low band spectrum (sub 1 GHz) for positioning and timing signals that penetrate buildings well, enabling deep indoor coverage. Low band spectrum with shorter signal wavelengths provides for less attenuation

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[31] *Id*.
[32] 911 Location Test Bed, LLC, *Report on Stage Z*, 129 (2018), https://api.ctia.org/wp-content/uploads/2018/08/911-Location-Test-Bed-Stage-Z-Report-Final.pdf ("Report on Stage Z").

of signals and greater penetration in-building where GPS signals struggle to penetrate indoor environments effectively. NextNav's terrestrial PNT system can provide accurate positioning data indoors where GPS signals may not reach reliably.

Improved accuracy in high-density areas. GPS signals can be obstructed or weakened in urban environments with tall buildings. Unlike GPS, NextGen PNT signals are over 100,000x stronger and do not require direct line of sight to a transmitter from to a receiver for determining the receiver's location. The solution overcomes many of the location challenges for the public safety community especially in urban environments where tall buildings with varying building materials can obstruct GPS signals (urban canyons and indoor coverage) as well as underground where a mobile device's direct visibility to GPS satellites is not available.

Barometric sensor-based Height above Terrain. Terrestrial PNT systems are limited with respect to estimating the height of the user equipment through multilateration because they operate from the same plane—terrestrial PNT antennas and receivers are roughly on the same vertical plane. Although GPS may be able to provide good vertical accuracy performance outside where there are no obstructions (tall buildings, trees, mountains, etc.), GPS is not able to determine the vertical location of a user where it is most needed for the public safety community in urban areas with multistory building structures for the reasons mentioned above—weak signal strength and inability to penetrate building materials plus lack of a direct line of sight to GPS satellites. To overcome these challenges, NextNav's NextGen 3D PNT solution also provides accurate z-axis (vertical location) in addition to x/y utilizing barometric pressure measurements from mobile devices. The height above terrain provides public safety users actionable location unlike the theoretical HAE received by many public safety agencies today.

NextNav's NextGen 3D PNT technology aims to provide single-digit horizontal accuracy (less than 10 meters) as well as vertical location accuracy within 3 meters, improving location accuracy beyond what it is today especially in urban and indoor environments—enabling improved emergency response times to assist PSAP telecommunicators and first responders.

NextNav presented simulation results in its FCC petition[33] exhibiting the accuracy that can be achieved with its terrestrial 3D PNT solution in indoor, urban, and rural areas using the methodology, network configuration, path loss, and fading channel model as described in 3GPP TRs 37.857 and 38.855. NextNav has shown that sub 10 meters x/y accuracy can be achieved at a 95% confidence level with 10 MHz bandwidth in the 900 MHz band.

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[33] *See Petition for Rulemaking of NextNav Inc.*, WT Docket No. 24-240, Exhibit A – Technical Appendix (Apr. 16, 2024), https://www.fcc.gov/ecfs/document/10416238018537/1.

NextNav's technology has also performed with a vertical location accuracy of less than 3 meters 94% of the time in an independently administered and transparent test bed process established to develop and validate a proposed z-axis (vertical) metric for indoor wireless 911 calls, as required by the FCC's 911 Location Accuracy Fourth Report & Order.[34] NextNav's vertical location has already been adopted across the emergency services ecosystems (including devices across every major wireless carrier).

Location data from NextNav's solution could be sent via the Text-To-911 service at the carrier's backend, similar to how emergency calls with 9-1-1 location-based routing are managed today, but with the added benefit of providing highly accurate location information to the communicator at the PSAP.

The combination of all the characteristics of a terrestrial PNT solution mentioned above is an important step in enabling the public safety ecosystem, providing the PSAP, agencies, and first responders with the tools needed for complementary and backup system for Emergency Services. For 9-1-1 callers, mobile carriers can benefit from a terrestrial PNT system by overcoming the challenges of location accuracy in urban areas, and indoor multi-story buildings. During the 9-1-1 intake and call taking process, time spent determining 9-1-1 caller location is reduced in cases where the estimated location has up to as much as 50 meters accuracy range and the location can't be matched/validated with the caller quickly to an actual building address. With time being critical, reliable single-digit x/y accuracy can allow dispatchers to focus instead on matching the closest available first responder resources needed at the incident. Once dispatched, first responders and incident commanders benefit from having a more accurate and reliable common view of the incident that can be visualized in 3D with the relative location of the 9-1-1 caller and the position of each responder.

NextNav NextGen 3D PNT Solution Serves as a Public Safety Backup to GPS

GPS is a fundamental technology that we rely on for much of our daily lives. Most of the public views GPS as a tool that smartphones use to figure out the fastest way from home to work or somewhere new, but in reality, we depend on GPS for much more than that. We rely on GPS for PNT that enables critical positioning data for emergency services as well as timing synchronization systems used in communication and data servers. For these reasons, there is a widespread consensus that the U.S. needs a terrestrial backup for GPS.

Imagine an emergency situation where GPS is not available for some period of time; this situation may create some inconveniences in our daily lives such as not having steady,

[34] Report on Stage Z at 129.

reliable power, not being able to use ride-share apps, or use GPS to get to a new place. For public safety, a backup for GPS is critical to incident response times where seconds matter—for all the benefits presented earlier in this document. NextNav's vision for it's NextGen 3D PNT capability is also complementary to GPS in that it can be enabled for standard 5G devices/mobile phones enabling 3D in indoor locations. A 9-1-1 caller's location could seamlessly be determined by shifting to NextNav's NextGen solution in the case of disruptions or lack of GPS signal whether the caller is indoors or outdoors. The vision is that dispatchers at the PSAP would have a seamless way to dispatch the closest responders to get help to the caller quickly. Incident commanders and first responders would also be able to seamlessly visualize the location of personnel at the incident for situational awareness.

With a backup centralized infrastructure and stronger signal strength, terrestrial PNT solutions, like NextNav's NextGen solution can be more resilient against certain types of disruptions, such as intentional jamming or spoofing attacks targeting GPS signals.

NextNav's NextGen 3D PNT solution also provides a backup timing synchronization solution—the "T" in PNT for timing. Timing information, for example, keeps servers across geographically disparate data centers accurately synchronized. Timing has also become increasingly important in the world of emergency response, with 9-1-1 dispatch and communication systems employing synchronized time solutions. Land Mobile Radio, which is relied on by public safety personnel for voice communications, relies on timing synchronization. Disrupting the system timing to delay call setup time, interrupt network transmitter sync, cause transmitter interference, and various latency between sites is a defined threat vector by CISA (Failure of Synchronization).[35] Additionally, as noted by CISA in its SAFECOM report on Cyber Risks to Land Mobile Radio, LMR systems are vulnerable to multiple cyber risks that could negatively affect critical communications.[36] One such vulnerability lies in the timing service and time synchronization because if the LMR system's time source is compromised, communications can be degraded or even incapacitated. The NextNav NextGen 3D PNT service proposed does not require costly expenditures by each agency to add secondary timing sources, as it will communicate natively with base stations needing a complementary or backup timing source via spectrum. This approach will provide agencies and users a more resilient LMR ecosystem that leverages a timing service, not a costly piece of hardware with a limited-service life.

The NextNav NextGen terrestrial 3D PNT solution will have time resiliency—in addition to resilient synchronization—atomic clocks with long holdover times, such as cesium clocks,

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[35] *See* CISA, *Cyber Risks to Land Mobile Radio, First Edition*, 4 (2023), https://bit.ly/3SW5CN0.
[36] *Id*. at 1.

can be available at one or more sites in a geographic market, and all the sites in a market will be interconnected by a fixed-wireless mesh. Only a few sites per market will require an independent timing source. Time synchronization resiliency can provide a backup so that 9-1-1 dispatch and communications systems can operate seamlessly when GPS is unavailable (relative timing synchronization is required to maintain call transfer for call setup time and avoid the threat vector of Failure of Synchronization referenced in the CISA document; NextGen has the relative synchronization needed by LMR systems).