Before the
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION
WASHINGTON, DC 20230

In the Matter of	)	
	)	
Development of a National Spectrum	)	Docket No. 230308-0068
Strategy	)	Document ID NTIA-2023-0003

COMMENTS OF THE GPS INNOVATION ALLIANCE

The GPS Innovation Alliance ("GPSIA") respectfully submits these comments in response to the National Telecommunications and Information Administration's ("NTIA") Request for Comments ("RFC") on the development and implementation of a National Spectrum Strategy ("Strategy").[1] GPSIA applauds NTIA's recognition that spectrum is a scarce resource that must be used efficiently and strongly supports NTIA's efforts to develop a comprehensive, long-term Strategy. That Strategy must carefully balance the identification of additional spectrum for, among others, broadband services, which GPSIA supports, with continued adherence to sound spectrum management decisions that consider incumbent operations and harmoniously accommodate diverse services in adjacent bands. In particular, GPSIA believes that the Strategy must acknowledge that the critical services provided to both federal and commercial users by Global Navigation Satellite Systems ("GNSS") like the U.S. Global Positioning System ("GPS") must continue to operate in a spectrum environment free from harmful interference.

[1] *See Development of a National Spectrum Strategy*, Request for Comments, NTIA, 88 Fed Reg. 16244 (Mar. 16, 2023) ("RFC").

I. INTRODUCTION AND SUMMARY

GPS-enabled technology has become a critical part of our national infrastructure over the last several decades, integrating itself more deeply every year. In addition to its vast and varied use across the federal government, GPS and the applications it supports create widespread economic benefits across a broad cross-section of industries, from manufacturing, surveying, mapping, and agriculture to construction, transportation, aviation, and emergency response. GPS-based technologies touch the lives of millions of Americans every single day, including those who depend on GPS for boating and other outdoor activities, and in their automobiles and farm vehicles, regardless of whether GPS is embedded in specialized devices or smart phones and tablets. Due in part to the stability of a quiet L-band spectrum environment, in which most GPS devices receive, GPS has become a highly innovative, successful, and ubiquitous technology that has injected almost $1.7 trillion into the nation's economy[2] and is critical to the smart infrastructure, services, and applications of today, tomorrow, and decades to come.

The satellites that transmit GPS signals are owned by the United States and operated by the U.S. Space Force, making the U.S. government's role in maintaining GPS's fundamental relationship to the nation's economy, infrastructure, and national security critical. And because GPS and GNSS play a central role in the daily activities of individuals and businesses worldwide, including for safety-of-life services, the Strategy presents an important opportunity for the U.S. government to endorse policies that ensure these systems are protected from harmful interference.

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[2] *See* RTI International, *Economic Benefits of the Global Positioning System (GPS)*, at ES-1 (June 2019), https://www.rti.org/sites/default/files/gps_finalreport.pdf (citing $1.4 trillion in 2017, which was converted to 2023 dollars using the U.S. Bureau of Labor Statics' CPI Inflation Calculator); Michael P. Gallaher, *Economic Benefits of the Global Positioning System (GPS), Presentation at the Positioning, Navigation and Timing Advisory Board Meeting* (Nov. 20, 2019), https://www.gps.gov/governance/advisory/meetings/2019-11/gallaher.pdf.

Toward this end, and because of the unique characteristics of GPS as a navigation system, which operates fundamentally differently than a communications system, NTIA should support a "zoning" approach to spectrum management when evaluating the introduction of new services in spectrum bands adjacent to GPS. It should also endorse the 1 dB interference-avoidance standard to protect GPS operations. Finally, NTIA should continue to adhere to the expertise of federal agencies charged with the management of GPS when making its spectrum management decisions. GPSIA looks forward to working with NTIA in the development of the Strategy in a manner that reflects the importance of GPS to our national infrastructure and to supporting NTIA's continued efforts to protect, preserve, and promote GPS.

II. COMMENTS

A. The Strategy Should Acknowledge the Unique Characteristics of GPS and the Need to Protect Mission-Critical Spectrum-Based Services.

The RFC appropriately notes that spectrum-based services will help the U.S. continue to lead the world in advanced technology and enhance our national and economic security.[3] GPSIA agrees and urges NTIA to recognize that spectrum-based services such as GPS have become an irreplaceable part of our national infrastructure. GPSIA further urges NTIA to recognize that, as a *navigation* system, GPS operates fundamentally differently from radio *communications* systems, with inherently different technical and functional attributes. For instance, while communications systems decode data bits, navigation systems measure the precise timing of bit transitions in order to derive precise timing and positioning information. These sub-nanosecond measurements of bit edges require wide receiver bandwidth, which also aids in effective multipath rejection.

[3] *See* RFC at 16245.

In addition, GPS devices depend on satellites that orbit more than 12,000 miles above the Earth and rely on solar panels to generate the power needed to transmit GPS signals. Those signals are received by GPS devices on the ground at power levels of less than a millionth of a billionth of a watt.[4] The low power levels at which GPS signals are transmitted and the distance over which they must travel result in transmitted signals that are well below the thermal noise floor when they are received on Earth. When coupled with the fact that GPS signals are spread spectrum, it is undeniable that GPS receivers must, unlike communications systems, perform the extraordinary engineering feat of extracting these faint signals from the noise, processing them, and delivering precise positioning, navigation, and timing information to end users.

Systems like GPS that support navigation functions are also sensitive to interference in different ways than systems that operate communications services. For GPS and GNSS systems to meet the needs of existing and future users, they must continue to be able to deliver and receive signals that are accurate, have integrity, and are available and continuous in nature. The

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[4] *See* Tim Bartlett, *Threats to GPS from Land-Based Signal Boosters*, POWER AND MOTORYACHT, (May 7, 2012), https://www.powerandmotoryacht.com/electronics/understanding-impactthreats-gps-land-based-signal-boosters ("GPS signals come from solar-powered 50-Watt transmitters 12,000 miles out in space."); *see also* Sebastian Anthony, *Think GPS is Cool? IPS Will Blow Your Mind*, EXTREMETECH, (Apr. 24, 2012), http://www.extremetech.com/extreme/126843-think-gps-is-cool-ips-willblow-your-mind ("Detecting a GPS signal on Earth is comparable to detecting the light from a 25-watt bulb from 10,000 miles.").

accuracy,[5] integrity,[6] availability,[7] and continuity[8] requirements of space-based navigation systems like GPS enable high-risk, high-consequence safety-of-life services that can be mission-critical to the U.S. government (or life-saving for consumers). Such systems differ greatly from consumer-grade terrestrial high-power communications systems operating above the noise floor. Indeed, the brief loss of connectivity in a communications system may be inconsequential – if even noticeable – during a non-emergency situation. In contrast, even minor increases in the effective noise floor can impede the ability of GPS receivers to extract navigation and timing signals from the noise, thereby degrading performance. And losing the mission-critical, safety-of-life services that rely on GPS – even momentarily – can prove catastrophic.

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[5] Accuracy is the difference between a GPS device's indicated position, velocity, and time ("PVT") and its actual PVT at any given moment. The accuracy requirements are highly use-case dependent, varying from tens of meters to less than a centimeter. In earthquake monitoring, for example, accuracy is extremely important both for measuring the imminence of quakes and for calculating post-quake displacement. Survey GNSS, precision agriculture, and intelligent transportation systems could not continue to function without accuracy. Yet, accuracy alone is insufficient for most GNSS applications; they also need integrity, availability, and continuity.

[6] Integrity is the ability of GNSS systems to provide timely warning to users of problems in the system or equipment and to shut itself down when it is unable to meet accuracy requirements. Safety-of-life aviation operations, such as precision approach and landing as well as Terrain Awareness Warning Systems, depend on integrity of the signal and system to avoid disasters and prevent loss of life. Without integrity, airport safety records would be worse and controlled flight into terrain accidents would rise. Like accuracy, integrity alone is insufficient to ensure functioning of GNSS.

[7] Availability describes how often a GNSS system is available for use when it satisfies accuracy and integrity requirements. A GNSS-based service that only provides PVT information with high integrity for short and unpredictable bursts is unsuitable for most applications. For example, even a momentary degradation of service during an aircraft precision approach or flight close to terrain may trigger a missed approach procedure requiring a pilot to climb to a safe altitude and then wait to be readmitted to the landing sequence. Simply put, all, if not most, ongoing uses require changes or suspension of operations if GNSS becomes momentarily unavailable. Data show that GPS, as it currently functions, meets service availability requirements nearly 100 percent of the time.

[8] Continuity evidences GPS's ability to provide the required level of service without unscheduled interruption. Momentary episodes of interference can significantly disrupt continuity for many use cases or applications. Providing high levels of continuity in the face of unpredictable and random interference is particularly difficult and may make potential applications of GNSS unviable. For example, the time between unscheduled interruptions must be long to ensure that standard surveying operations can be conducted, driverless cars can navigate down the highway, and ambulances can reach unfamiliar destinations.

B. A "Spectrum Zoning" Approach Can Be Effective in Providing Interference Protection.

While recognizing the importance of spectrum-based services, NTIA seeks to develop a pipeline of spectrum for the Strategy that can be studied for repurposing to meet future requirements for non-federal and federal use alike.[9] The RFC notes that the Strategy should be informed by ideas and techniques for how to identify the potential for – and protect against – interference that incumbents in adjacent bands may experience when repurposing spectrum.[10]

GPSIA appreciates NTIA's focus on identifying spectrum for repurposing and the spectrum co-existence tools that may enable enhanced spectrum use. But NTIA should also recognize the vital need of GPS to operate in an interference-free environment and seek to protect GPS from both in-band *and* adjacent-band interference, particularly when services in adjacent spectrum bands operate at higher power levels. New spectrum use cases should *not* result in degradation, harmful interference, or the loss of access to spectrum to or amongst incumbent users.

GPSIA therefore urges NTIA to consider the use of a "zoning" approach when evaluating opportunities for new spectrum uses, particularly if a newly introduced service has the potential to cause interference to GPS. A zoning approach would group similar spectrum-based services together, to the greatest extent possible, to minimize the number of band edges or "border areas" where dissimilar uses in close proximity create serious interference challenges. A zoning approach would not only produce a stable and quiet radio environment that would protect vital services provided by incumbent users, such as GPS, but it would also ensure regulatory predictability that would facilitate the development of new services.

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[9] *See* RFC at 16245 (Pillar #1).

[10] *See* RFC at 16246 (Pillar #1).

A zoning approach would also obviate the need to develop new capabilities and techniques to ensure compatibility among different services. Although the technology embedded in GPS-reliant devices is constantly being updated, those capabilities and techniques often require long acquisition lead times and must be supported by significant investments to perform the underlying research, development, testing, and evaluation, particularly when they must be integrated into military, aviation or other high-risk operations. Moreover, as the Ligado proceeding before the Federal Communications Commission ("FCC") has demonstrated, while some techniques to mitigate interference may suit communication systems, they may be ineffective in assessing potential deleterious effects on navigation systems.[11] A zoning approach that minimizes the number of dissimilar spectrum allocations in close spectral proximity to each other would avoid instances of incompatible use in the first place. Indeed, had the FCC used a zoning approach and maintained the well-established "quiet neighborhood" for GPS operations in the Ligado proceeding, it would have avoided the yearslong conflict and regulatory instability it created.

C. The 1 dB Metric is the Most Comprehensive and Informative Choice for Evaluating Harmful Interference to GPS.

Importantly, the RFC asks how the Strategy may be informed by prior experience and interference protection assessments to avoid unnecessary delays resulting from non-consensus.[12] NTIA should base its Strategy on prior successes, including proven mechanisms to avoid harmful interference. Specifically, in addition to a zoning approach, NTIA's spectrum management decisions should embrace the 1 dB metric as the appropriate interference protection

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[11] *See Ligado Amendment to License Modification Applications, IBFS File Nos. SES-MOD-20151231-00981, SAT-MOD-20151231-00090, and SAT-MOD-20151231-00091*, Order and Authorization, 35 FCC Rcd 3772 (2020).

[12] *See* RFC at 16247 (Pillar #2).

criterion to determine spectrum compatibility between GNSS systems like GPS and other services. This metric, which measures whether a new service causes a 1 dB degradation in a receiver's reported Carrier-to-Noise Power Density Ratio ("C/N_0"), corresponds to a 25-percent increase in the noise floor and is based upon well-understood GNSS engineering considerations, with equally well-understood effects on receiver operation.

The 1 dB metric provides a universal ability to assess receiver performance because it is associated with quantifiable changes in the overall noise to which GNSS receivers are subject. And it can quantify the effects of interference on GNSS receivers from both in-band *and* out-of-band emissions. Out-of-band emissions create a phenomenon known as "overload" interference. Overload interference occurs when extremely powerful transmissions in nearby bands overwhelm the front-end filtering in the GNSS receiver, saturating the receiver electronics and degrading its performance. As noted above, GPS receivers are designed to receive faint GPS signals transmitted from thousands of miles away and therefore must be protected from high-power terrestrial transmissions both in *and* outside the frequency band in which the receiver is designed to operate.

Use of the 1 dB interference standard is particularly necessary to accommodate the technical characteristics of navigation receivers and ensure the accuracy, integrity, continuity, and availability of GNSS signals. For example, most GNSS systems rely on continuous tracking of the signal carrier of each satellite being tracked in order to maintain maximum accuracy and integrity. By continuously tracking the carrier and measuring its phase at the time of measurement (the "carrier phase"), relative movement with respect to the satellites can in turn be tracked at sub-centimeter levels. A 1 dB decrease in C/N_0 within the spectrum band, however, causes a tenfold decrease in the mean time between cycle slips in a GNSS receiver tracking loop.

Cycle slips, in turn, interrupt the continuous carrier phase, forcing the tracking loop to reacquire the carrier and then re-initiate the carrier phase measurement. In other words, the measurement cycle is interrupted and must be restarted. This lack of continuous carrier phase renders many high precision applications unavailable.

Similarly, all GNSS applications track the pseudo random noise code ("PRN code") from selected satellites in view – this is accomplished in the code tracking loop. The code tracking loop synchronizes a locally generated replica PRN code with the PRN code broadcast from the satellite, which allows the receiver to make a precise measurement of the starting edge of the first bit of the PRN sequence as it repeats. With this code phase information, the receiver can determine how long it took the satellite signal to reach the receiver and consequently determine the distance to the satellite. However, as the noise floor rises, the increased noise makes it more difficult to precisely synchronize the replica PRN code to the broadcast signal, introducing error into the measurement of distance to the satellite. Such errors begin to accrue in noticeable ways before the point at which there has been a full 1 dB reduction in C/N_0; therefore, it is critical that interference levels not be permitted to exceed the 1 dB metric.

Recent analyses conducted by the National Academies of Sciences, Engineering, and Medicine ("NASEM"),[13] as directed by Congress,[14] confirm that an approach to interference analysis based on C/N_0, which NASEM more generally referred to as signal-to-noise ("SNR") ratio, is the appropriate mechanism for evaluating harmful interference to GPS receivers.[15]

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[13] *See* National Academies of Sciences, Engineering, and Medicine, *Analysis of Potential Interference Issues Related to FCC Order 20-48* (2022) ("NAS Report"), https://doi.org/10.17226/26611.

[14] *See* William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283, 134 Stat. 3388, 4074 § 1663.

[15] *See* NAS Report at 2, 37 (finding that the use of an SNR ratio would be a more "comprehensive and informative" approach to evaluating harmful interference to GPS devices than the approach used by the FCC in the Ligado proceeding).

NASEM found that a C/N_0-based approach is more predictive of receiver performance and, therefore, can help identify harmful interference across a broad set of use cases.[16] Indeed, NASEM recognized that the 1 dB metric would "preclude[] harmful interference in virtually all use cases."[17]

As the GPS industry has repeatedly explained to the FCC,[18] the 1 dB metric has for years been relied upon internationally by the GNSS industry and by regulators around the world when designing, operating, and evaluating GPS receivers. Given the very long useful life of GPS receivers as well as the fact that GPS-enabled equipment can be highly integrated in devices used by federal agencies for mission-critical services, GPSIA urges NTIA to make sure that the Strategy acknowledges that the 1 dB metric remains the most appropriate tool for assessing harmful interference to GNSS services like GPS.

D. The Strategy Must Acknowledge the Expertise of Federal Agencies in Considering Future Spectrum Allocations.

Finally, the RFC seeks comment on the development of spectrum management processes to better promote important national goals in the short-, medium-, and long-term, *without* jeopardizing critical government missions.[19] As noted above, NTIA must base its spectrum management plans on two mechanisms – a spectrum zoning approach and a 1 dB protection criterion – to protect the vital GPS services on which federal users rely from harmful interference. NTIA should also acknowledge that federal agencies have significant expertise in

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[16] *See* NAS Report at 2-3, 42.

[17] NAS Report at 37.

[18] *See, e.g.*, Comments of the GPS Innovation Alliance, ET Docket No. 17-340, at 5-6 (filed Jan. 31, 2018) (noting, for example, that the International Telecommunication Union has consistently applied an interference to noise ratio of -6 dB (equivalent to a 1 dB rise in the noise floor) in proceedings related to GNSS, other non-communications services, and some radiolocation services).

[19] *See* RFC at 16246 (Pillar #1)

how to evaluate that harmful impact and leverage their expertise when determining how to manage spectrum and whether new services should be introduced in a band.

The Ligado proceeding before the FCC represents a prime example of how better coordination with federal agencies could have avoided the regulatory stalemate that has resulted. As NTIA is aware, 14 federal agencies and departments opposed Ligado's proposed deployment of a terrestrial service in the L-band on the basis that this new use of spectrum, which would fundamentally depart from decades of sound spectrum management and upset the spectrum environment which allowed L-band satellite services to flourish, would "cause unacceptable operational impacts to the warfighter and adversely affect the military potential of GPS by negatively impacting GPS receivers."[20] Similarly, the U.S. Department of Transportation – a neutral third-party expert on GPS and the country's civil lead on GPS issues – confirmed, as part of its lengthy Adjacent Band Compatibility Assessment,[21] that a substantial number of GPS receivers would suffer interference from such terrestrial operations.

Utilizing that data, NTIA compiled further compelling evidence of the harmful interference that would be caused by Ligado's proposed terrestrial network and the impact it will have on the day-to-day operation of GPS devices in the U.S.[22] NTIA stated that "federal agencies have significant concerns regarding the impact to their missions, national security, and the U.S. economy" and therefore NTIA was "unable to recommend the Commission's approval

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[20] Memorandum from Thu Luu, Executive Agent for GPS, Department of the Air Force, to IRAC Chairman at 1 (Feb. 14, 2020).

[21] *See* U.S. Department of Transportation, *Global Positioning System (GPS) Adjacent Band Compatibility Assessment*, Final Report (Apr. 2018), https://www.transportation.gov/pnt/global-positioning-system-gps-adjacent-band-compatibility-assessment.

[22] *See generally Assessment of Compatibility Between Global Positioning System Receivers and Adjacent Band Base Station and User Equipment Transmitters*, Technical Memorandum, NTIA TM-20-536 (Dec. 2020), *attached to*, Letter from Kathy Smith, Chief Counsel, NTIA, to Marlene H. Dortch, Secretary, FCC, IB Docket Nos. 11-109, 12-340, *et al.* (filed Dec. 4, 2020) (using the accepted 1 dB C/N_0 metric).

of Ligado's applications."[23] Despite these concerns, the FCC proceeded with approving Ligado's proposed network, which, as noted above, NASEM has now further confirmed will cause harmful interference. To avoid this result in the future, GPSIA urges NTIA, along with the FCC, to continue to rely on the expertise of federal agencies charged with the management of GPS when considering the introduction of new adjacent-band services.

III. CONCLUSION

GPSIA appreciates NTIA's efforts to develop a long-term spectrum strategy. As part of that effort, NTIA should recognize the critical difference between communications and navigation systems and support the maintenance of a spectrum environment that groups like services together. It also should continue to endorse the 1 dB metric for evaluation of harmful interference to navigation services and rely on the expertise of federal stakeholders responsible for the operational management of (or that otherwise rely on) these spectrum-based services. These spectrum management tools have maximized spectrum efficiency and allowed GPS, in particular, to become the world-leading and ubiquitous navigation technology that it is today.

Sincerely,

/s/ F. Michael Swiek

F. Michael Swiek
Managing Director
GPS Innovation Alliance

April 17, 2023

[23] Letter from Douglas W. Kinkoph, Deputy Assistant Secretary for Communications and Information (Acting), NTIA, to Ajit Pai, Chairman, FCC (Dec. 6, 2019).