Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
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Office of Engineering and Technology Seeks	)	ET Docket No. 17-340
Comment on Technological Advisory Council	)	
Spectrum Policy Recommendations	)	

COMMENTS OF THE GPS INNOVATION ALLIANCE

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The GPS Innovation Alliance ("GPSIA")[1/] submits these comments in response to the Public Notice issued by the Office of Engineering and Technology ("OET"), seeking comment on the spectrum policy recommendations that the Technological Advisory Council ("TAC") made to the Commission through a series of white papers.[2/] GPSIA appreciates the spectrum management efforts made by the TAC and the Commission, but cautions against adopting policies that do not adequately take into consideration fundamental distinctions in different services – particularly navigation and communications services – and their different levels of susceptibility to potential interference. The method for determining the potential for interference to navigation systems is well-established. The Commission should therefore recognize, as part of its spectrum management principles, the impact that a 1 dB decrease in the carrier-to-noise

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1/ GPSIA was formed in February 2013 to protect, promote, and enhance the use of Global Position System ("GPS") and Global Navigation Satellite System ("GNSS") technologies. Members and affiliates of GPSIA come from a wide variety of fields and businesses reliant on GPS, including manufacturing, aviation, agriculture, construction, transportation, first responders, surveying, and mapping. GPSIA also includes organizations representing consumers who depend on GPS for boating and other outdoor activities and in their automobiles, smartphones, and tablets.

2/ *Office of Engineering and Technology Seeks Comment on Technological Advisory Council Spectrum Policy Recommendations*, ET Docket No. 17-340, Public Notice, 32 FCC Rcd 10160 (rel. Dec. 1, 2017) ("*Public Notice*").

density ratio ("C/N_0") has on navigation services and the actions that transmitter manufacturers *can*, and as a matter of public policy *should* take, to protect against those increases.

I. EXECUTIVE SUMMARY

In considering spectrum management principles, the Commission must take into consideration the fundamental differences between navigation and communications systems. With respect to navigation bands, the Commission should recognize the internationally established criteria -a 1 dB decrease in C/N_0 as an interference protection criterion, which ensures that a harmful interference level is prevented in the first place, so that systems operating in the same or adjacent bands do not interfere with one another. It is also unrealistic for the Commission to expect receivers to block *all* signals outside the band in which they receive, irrespective of the impact to receiver cost, performance, and design. Commission policies on spectrum management must also take into account its central – and statutorily mandated role as the arbiter of spectrum use; the Commission must not abdicate it obligations in favor of an approach that disregards differences between technologies and applications. When considering new services, the burden to demonstrate a lack of harm to incumbent operations should be on new entrants. Finally, as GPSIA has stated before, the use of risk-informed interference assessment ("RIIA") to establish Harm Claim Thresholds ("HCT") is problematic.

II. INTRODUCTION

OET seeks comment on spectrum policy recommendations that the TAC made to the Commission through three white papers.[3/] The TAC recommends that the Commission: (1)

3/ *See* FCC TECHNOLOGICAL ADVISORY COUNCIL, BASIC PRINCIPLES FOR ASSESSING COMPATIBILITY OF NEW SPECTRUM ALLOCATIONS (rel. 1.1 2015), *available at* https://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting121015/Principles-White-Paper-Release-1.1.pdf ("BASIC PRINCIPLES WHITE PAPER"); FCC TECHNOLOGICAL ADVISORY COUNCIL, A QUICK INTRODUCTION TO RISK-INFORMED INTERFERENCE ASSESSMENT (ver. 1.00 2015), *available at*

implement the TAC's Basic Spectrum Management Principles ("Basic Principles") as policies; (2) adopt RIIA and statistical service rules; and (3) improve the interference resolution and enforcement process.[4/] The Public Notice states that comments will be considered by the TAC to update its recommendations, and specifically requests comment on how the principles proposed by the TAC may be incorporated in the Commission's spectrum policy.

Over the last 30 years, Global Positioning System ("GPS")-enabled technology has become a critical and irreplaceable part of our national infrastructure, and it becomes more deeply ingrained every year. The growth of GPS-enabled technologies is dependent on rigorously developed technical rules, interference protections, and a universally stable and predictable spectrum environment. In order to ensure that a broad range of spectrum-based services can co-exist, the Commission's spectrum policy must consider policy and public interest concerns relevant to those diverse services, including the protection, at internationally-accepted levels, of certain devices, such as Global Navigation Satellite System ("GNSS") receivers, that are vulnerable to interference. The importance of GPS and GNSS to safety-of-life, the domestic and global economies, and the daily activities of individuals worldwide, make it critical that these systems be protected from harmful interference in a manner that is universal and predictable. In considering spectrum management principles, GPSIA therefore urges the

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http://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting4115/Intro-to-RIA-v100.pdf ("RIIA WHITE PAPER"); FCC TECHNOLOGICAL ADVISORY COUNCIL, A STUDY TO DEVELOP THE NEXT GENERATION SYSTEMS ARCHITECTURE FOR RADIO SPECTRUM INTERFERENCE RESOLUTION (ver. 1.0 2016), *available at* https://transition.fcc.gov/oet/tac/tacdocs/reports/2016/A-Study-to-Develop-a-Next-Generation-System-Architecture-V1.0.pdf ("INTERFERENCE RESOLUTION WHITE PAPER").

4/ *See Public Notice* at 10160-61.

Commission to establish clear, reasonable, and internationally-harmonized protection criteria for such services.[5/]

III. BASIC SPECTRUM MANAGEMENT PRINCIPLES

A. Principles 1-3 – Interference Realities

The TAC suggests that there are certain aspects of interference that all participants in a wireless communications ecosystem must consider. It therefore recommends recognition of three principles associated with interference. *First*, both transmitting and nearby receiving services contribute to harmful interference. *Second*, all services should expect non-harmful interference from nearby signals that, up to a certain limit, is tolerable. *Finally*, due to the unpredictable nature of an electromagnetic environment, the Commission should not base any radio service rules on unusual circumstances and operators should expect and prepare for occasional service degradation and interruption.[6/]

1. "Interference Realities" Must Take Into Account the Difference Between Communications and Navigation Systems

The TAC is correct that the potential for interference depends on characteristics of both transmitters and receivers. However, that assertion and the conclusion that follows – reflected as the second principle that services should plan for non-harmful interference – gives insufficient consideration to distinctions between services and implies that "interference" is a monolithic concept. It is not. The TAC spectrum management principles are limited because they fail to acknowledge that a meaningful discussion of "interference" and effective guidelines for protection must first recognize the elemental difference between navigation and communications

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5/ *See* Comments of GPS Innovation Alliance, ET Docket No. 17-215 at 2, 8 (filed Oct. 30, 2017); Comments of GPS Innovation Alliance, ET Docket No. 16-191 at 5, 8 (filed Aug. 11, 2016).

6/ BASIC PRINCIPLES WHITE PAPER at 7-13; *Public Notice* at 10162.

systems and the resulting differences in interference susceptibility between the two. As GPSIA has noted to the Commission before,[7/] GNSS, as a navigation system, operates differently than radio communications systems, with inherently different functionality and with different technical attributes. Applying the interference principles TAC proposes to navigation systems is inappropriate and will create unacceptable risks.

In comparison to communications systems, the primary measurement in GNSS is the precise timing of bit transitions in the navigation signal. Precise timing and positioning requires sub-nanosecond measurement of bit edges and effective multipath rejection. Both, in turn, require wide receiver bandwidth. In addition, unlike communications systems, which operate above the noise floor, spread spectrum GPS signals are below the thermal noise floor when they are received. Thus, even minor increases in the effective noise floor impede the ability of GNSS receivers to extract signals from the noise, thereby degrading performance.

2. Assessments of Interference Impact on GNSS Must Be Based on a 1 dB Decrease in Carrier-to-Noise Density Ratio (C/N_0)

The TAC spectrum management principles must recognize that GNSS receivers should not be required to tolerate interfering signals that cause a greater than 1 dB decrease in C/N_0. Accordingly, it is imperative that the Commission adopt policies that recognize that metric in navigation bands. Such policies must be harmonized with domestic and international standards; specifically, the 1 dB Standard for harmful interference.

For example, the International Telecommunications Union ("ITU") has consistently applied an interference to noise ratio ("I/N") of -6 dB (equivalent to a 1 dB rise in the noise floor) in proceedings related to GNSS, other non-communications services, and some

7/ *See, e.g.*, Comments of the GPS Innovation Alliance, ET Docket No. 16-191, at 2 (filed Aug. 11, 2016).

radiolocation services. In other words, aggregate interference is limited to a 1 dB increase in the overall noise floor, and, in GNSS receivers, this is most readily observed as a 1 dB decrease in C/N_0. U.S. governmental agencies agree, recognizing that the 1 dB Standard is necessary to protect GPS operations from harmful interference.[8/] The ubiquity of the 1 dB Standard in the ITU and other domestic and international proceedings reiterates the importance of characterizing and understanding the noise floor and validates the work TAC has previously proposed to undertake.

In particular, GPSIA notes several technical characteristics of navigation receivers that mandate adoption of the 1 dB standard. First, GPSIA notes that a 1 dB decrease in C/N_0 within the RNSS band would cause a tenfold decrease in the mean time between cycle slips in a GNSS receiver tracking loop as shown in Figure 1 below. Most GNSS systems rely on continuous tracking of the signal carrier of each satellite being tracked in order to attain maximum accuracy. By continuously tracking the carrier and measuring its phase at the time of measurement (the "carrier phase"), relative motion with respect to the satellites can be ascertained at sub-centimeter levels. A cycle slip interrupts this continuous carrier phase, forcing the tracking loop to reacquire the carrier, and then re-initiate the carrier phase measurement. Lack of continuous carrier phase renders many high precision applications unavailable.

8/ *See Background Paper on Use of a 1-dB Decrease in C/N_0 as GPS Interference Protection Criterion*, UNITED STATES AIR FORCE, at Section 8(a), https://www.gps.gov/spectrum/ABC/1dB-background-paper.pdf (last accessed Jan. 30, 2018); STEPHEN MACKEY, HADI WASSAF, & KAREN VAN DYKE, DOT GPS ADJACENT BAND COMPATIBILITY ASSESSMENT TEST RESULTS (2017), https://pdfs.semanticscholar.org/7468/1f17152e5953cfeeb54ff7def4e8496e897a.pdf.

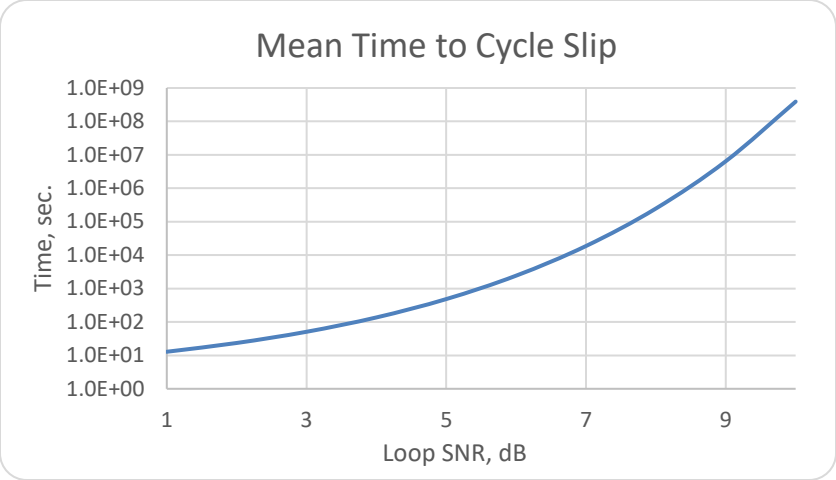

Figure 1: Mean Time to Cycle Slip

In addition, 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. This synchronization 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 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, resulting in increased error in the measured distance to the satellite. In dynamic applications with wider tracking loop bandwidths, small increases in the noise floor yield substantial changes in Coarse Acquisition code tracking error, especially in reduced signal scenarios in which the receiver is operating close to its acquisition sensitivity threshold.

Degradation may also occur before the point at which there has been a 1 dB decrease in C/N_0, or before the point at which the noise due to interference has increased by 25 percent. This is particularly true in challenging use cases in which signal levels may be attenuated by foliage or structures (for example, suburban streets or "urban canyons," respectively), or in which signal

reception is changing due to dynamic effects, such as large trucks passing on the highway or aircraft "pitch and roll" during normal maneuvering at takeoff, landing, or en route. It is critical that the margin established in the design of the GPS system for effects such as these not be eroded as spectrum use evolves. Thus, GPSIA encourages the commission to respect the internationally recognized 1 dB standard for harmful interference to navigation receivers.

3. The Proposed Principles of "Interference Realities" Do Not Adequately Describe the Commission's Role in Spectrum Management

The TAC's formulation of interference considerations does not adequately take into consideration the Commission's statutory obligation over spectrum management, and the array of regulatory and policy tools the Commission possesses to manage interference to critical navigation services like GNSS. Those policy tools establish transmit power and out-of-band emission ("OOBE") limits, compatible spectrum "neighborhoods," guard bands, self-certification (*i.e.*, where a manufacturer self-certifies that a device operates successfully and will suffer no harmful interference for its intended use), and specific receiver performance requirements.[9/] Determining which tool to use depends on a number of factors, including the nature of the services in the adjacent bands and the types of receivers utilized.[10/] For example,

9/ *See* Comments of the GPS Innovation Alliance, ET Docket No. 13-101, at 3-4 (filed July 22, 2013).

10/ *See id.*

the accuracy,[11/] integrity,[12/] availability,[13/] and continuity[14/] requirements of space-based navigation services and safety-of-life systems differ greatly from those of terrestrial high-power communications systems. Such dissimilar systems demand radically different models and assumptions when considering interference. Safety-of-life services require careful margin calculations and distinct analytical tools.

The proposed principle that services must plan for occasional interference is inconsistent with the Commission's central role in spectrum management, particularly with regard to

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11/ 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.

12/ 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.

13/ 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% of the time. *See* Wm. J. Hughes Technical Center, Global Positioning System (GPS), Standard Positioning Service (SPS), Performance Analysis Report, Report #92 (2016), *available at* http://www.nstb.tc.faa.gov/reports/PAN92_0116.pdf.

14/ 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.

exercising the rulemaking authority pursuant to which the Commission is tasked with considering varying technical and operational standards, requirements, and environments.[15] While certain extreme scenarios are always possible, services should not be required to anticipate and plan for circumstances that the *Commission* can and should control. If the Commission allows an increase in the noise floor in spectrum occupied by GNSS receivers it, and not receiver manufacturers, will be responsible.

It is also overly simplistic to suggest that all services should be expected to absorb "occasional service degradation or interruption."[16/] The impact of service degradation or interruption varies dramatically by service.[17/] During non-emergency situations, the brief loss of television reception, cellular wireless service, or access to an unlicensed hotspot (*e.g.*, Wi-Fi) may be inconsequential. However, losing public safety, aviation, or other navigation services that rely on GNSS reception – even momentarily – could prove catastrophic.

15/ *See* 47 U.S.C. § 303; Comments of the GPS Innovation Alliance, ET Docket No. 17-215, at 7-9 (filed Oct. 30, 2017).

16/ *See* BASIC PRINCIPLES WHITE PAPER at 12-13.

17/ As noted above, it is critical that the Commission understand the unique accuracy, availability, integrity, and continuity requirements for safety-of-life navigation services such as GNSS.

B. Principles 4-6 – Responsibilities of Radio Services

The TAC suggests that receiving systems are responsible for mitigating interference created and received by transmitting services in adjacent bands. The TAC recommends that the Commission adopt three principles associated with these responsibilities. *First*, receivers must block interference outside their aside channels. *Second*, systems should implement techniques at all layers to mitigate degradation from interference. *Finally*, transmitters, in addition to receivers, are also responsible for mitigating interference.

As explained in detail above, the TAC's observations about interference do not take into consideration the differences between communications and navigation systems. Moreover, stating that receivers are responsible for mitigating interference – particularly GNSS receivers – ignores the fact that only transmitters cause a decrease in the carrier–to-noise ratio – the relevant metric for measuring interference to GNSS devices. Navigation devices are not capable of controlling that key parameter in the radiofrequency ecosystem. The Commission is in the best position to evaluate how new transmitting services will affect incumbent services, particularly navigation services such as GNSS, that is, whether the effective noise floor in the receiving spectrum will be unacceptably elevated.

The Commission must maintain its role in managing the spectrum environment and grouping like services in order to maximize spectrum efficiency. Both the FCC and the ITU have historically maintained a quiet radio frequency spectrum neighborhood for GNSS receivers, along with other technologies that utilize faint radio signals and sensitive receivers – a spectrum neighborhood populated by similar users. As noted in an IEEE Paper, "[t]aken together, the measurement data in this study send a message – regulation must be very sensitive to the function of the band, because the rules determine the radio environment. Open bands, like the ISM band, do become populated with the man-made signals. This openness results in many

terrestrial users and great utility, but does render the band useless for space-base-based applications. . . . The GPS band serves safety-critical applications everywhere."[18/]

Of course, receivers can be designed to block some signals outside their bands, as the TAC suggests. However, the TAC's observation that receivers are responsible for blocking *all* signals outside their band is simplistic.[19/] No receiver blocks all signals outside the band. On its own, the TAC acknowledges, "ideal receivers" can mitigate all interference, but "[a]ctual receivers can only provide a finite amount of rejection of unwanted signals outside the assigned channels."[20/] A variety of factors – both internal and external to receiver design – affect a receiver's ability to block signals. In some cases, differences between types of services and the physical proximity of their devices negate any possibility of coexistence. For example, receiver sensitivity and dynamic range coupled with the power delta between transmitter and receiver impose laws-of-physics restrictions on receiver blocking. Further, size and cost constraints limit the ability of a receiver to implement any and all types of mitigation strategies. And in some receivers, improvements in receiver blocking come at the expense of receiver performance.

Moreover, as a matter of public policy, the Commission should not expect receiver manufacturers to block any potential interfering signals *irrespective of the impact to receiver cost, performance, or design*. While receiver manufacturers should follow responsible system design practices, they should not be required to use all possible techniques to accommodate any

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18/ Juyong Do, Dennis Akos, & Per Enge, *L and S Bands Spectrum Survey in the San Francisco Bay Area*, in IEEE Position Location and Navigation Symposium, 2004, April 26-29, 2004, at Section V, *available at* http://ieeexplore.ieee.org/document/1309043/ (last accessed Jan. 31, 2018). The IEEE Paper is based on a NASA-sponsored study conducted by Stanford University. *See* Per Enge, Joel B. Simoneau, L. Wilson Pearson, & Venkatesh Seetharam, *Measurements of Man-Made Spectrum Noise Floor*, NASA CR-2004-213551, *available at* http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20050041714.pdf (last accessed Jan. 19, 2018).

19/ BASIC PRINCIPLES WHITE PAPER at 14.

20/ *Id.*

and every adjacent service, especially those techniques that will adversely affect the performance, cost, or availability of the established service. In general, it is contrary to the public interest to impose a blanket coexistence requirement for all services. It is well known that some mitigation techniques suit communications systems but may have deleterious effects on navigation systems. The public interest requires that the Commission actively engage in a qualitative discussion that takes account of service requirements, customer expectations, and safety factors, rather than sanction a spectrum "free for all."

Anticipating future spectrum expansion demands a stable and well-regulated spectrum environment. The TAC notes, "[a]ssuming good engineering practice, a receiver would be deployed with proper filtering and dynamic range to accommodate future expansion of the spectrum, as it was intended for."[21/] But a receiver design that anticipates future expansion of allocated spectrum is fundamentally different than planning for unforeseeable changes to spectrum allocation and service type.

C. Principles 7-9 – Regulatory Requirements and Actions

In the final three principles, the TAC recommends that the Commission adhere to particular requirements and take certain actions to gather technical information about the operations of incumbent and new services, levels of harmful interference, and the interactions between services in expected conditions. The TAC argues that this information will enable the Commission to make informed decisions regarding frequency allocations.[22/]

GPSIA agrees that the Commission should make quantitative analyses before it permits the introduction of new services. The burden must remain on the new service to demonstrate

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21/ *See* BASIC PRINCIPLES WHITE PAPER at 16.

22/ *Id.* at 18-23; *Public Notice* at 10163.

that it will not disrupt incumbent operations. The demonstration should be based on clear, pre-defined, and internationally harmonized standards that the Commission has embraced.[23/] As noted below, however, quantitative analyses cannot be the only tool for determining whether a new service should be introduced. The Commission must also consider the extent and cost of impacts to the embedded user base from new services. Likewise, it must weigh economic and human costs to incumbent services against the potential benefit from new services, giving priority to safety-of-life service, among others.

IV. RISK INFORMED INTERFERENCE ASSESSMENT

The TAC proposes that the Commission implement RIIA and statistical service rules more widely.[24/] According to the TAC, the Commission should conduct a quantitative risk assessment and publish the assessment's results, as proposed in the TAC's 2015 introductory guide.[25/] The TAC believes that a quantitative assessment will enable it to provide "objective and actionable information to Commissioners weighing the benefits of a new service against its adverse technical impact on incumbents."[26/]

The use of RIIA to establish HCTs, as the TAC has previously advocated, is problematic for several reasons.[27/] Use of HCTs breaks with regulatory precedent and reassigns the burden of proof of interference on incumbents. The HCTs approach places the burden of policing

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23/ As discussed above, GPSIA supports the use of the 1 dB standard, as recognized by the ITU, DoT, and others. Comments of the GPS Innovation Alliance, ET Docket No. 16-91, at 5 (filed Aug. 11, 2016).

24/ RIIA WHITE PAPER at 1-3; *Public Notice* at 10164.

25/ *See* RIIA WHITE PAPER at 1-3.

26/ *Id.* at 11.

27/ *See* Comments of the GPS Innovation Alliance, ET Docket No. 13-101 at 4-6 (filed July 22, 2013).

interference on existing spectrum users; however, there is no guarantee that even well-intentioned new entrants working with existing users will be able to design their services and implement operations in a way which will avoid interference below a given harm claim threshold. As the TAC's previous White Paper recognizes,[28/] the case of Nextel's implementation of mobile technology and its effects on public safety users in the 800 MHz band provides one example where parties acting in good faith still created substantial interference issues. Although the Commission ultimately decided to reconfigure the 800 MHz band, it first urged the parties to make voluntary technical changes to prevent or reduce interference at particular sites.[29/] This approach was not successful, and the parties suggested that the Commission address interference disputes on a case-by-case basis. The Commission rejected this proposal, noting that "[a]ddressing interference on a case-by-case basis is both labor-intensive and expensive."[30/] Relying on Commission complaint procedures to sort out widespread interference issues after the fact under an HCTs approach would expose parties to significant harms, disruption, and confusion, as well as the expense of identifying interference sources and pursuing resolution through protracted and inefficient complaint proceedings. As was the case with the initial approach in the 800 MHz band, relying on the complaint process as the principal regulatory mechanism for addressing interference would likewise severely tax the

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28/ *See* RECEIVERS AND SPECTRUM WORKING GROUP, FCC TECHNOLOGICAL ADVISORY COUNCIL, INTERFERENCE LIMITS POLICY: THE USE OF HARM CLAIM THRESHOLDS TO IMPROVE THE INTERFERENCE TOLERANCE OF WIRELESS SYSTEMS, 56-61 (2013), *available at* http://transition.fcc.gov/bureaus/oet/tac/tacdocs/WhitePaperTACInterferenceLimitsv1.0.pdf.

29/ *See Improving Public Safety Communications in the 800 MHz Band, et al.*, Report and Order, Fifth Report and Order, Fourth Memorandum Opinion and Order, and Order, 19 FCC Rcd 14969, ¶ 14 (2004).

30/ *Id.* ¶ 17.

Commission's existing resources and would leave interference issues unresolved for long periods of time without the hiring of new staff and/or allocation of additional resources.[31/]

Use of HCTs drastically departs from the expectation the Commission has created for manufacturers of a stable spectrum environment. Manufacturers rely on the Commission to ensure that rules do not routinely change in making the investments necessary for research, development, and production. The Commission has long recognized this need to ensure regulatory certainty in order to spur investment.[32/] The Commission must therefore balance the desire to facilitate flexible use of spectrum via HCTs against the risk of creating a fundamentally unpredictable environment that discourages manufacturers from investing in the development and production of equipment that may be rendered prematurely obsolete as HCTs are adjusted based on changing social and economic factors. Existing spectrum users, such as the various industry segments that rely on GPS and the industry that supplies GPS-based technology, have already invested many billions of dollars in their systems to provide critical services requiring high reliability and integrity, including those used in public safety, aviation, and many commercial environments.[33/] Investments such as these would be seriously jeopardized if the Commission were to find that new entrants should be permitted to operate at increasing

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31/ *Id*.

32/ *See, e.g.*, *Amendment of Part 90 of the Commission's Rules to Adopt Regulations for Automatic Vehicle Monitoring Systems*, Report and Order, 10 FCC Rcd 4695, ¶ 16 (1995) (acknowledging that "uncertainty about possible changes in our rules has deterred or prevented [entities] from committing greater capital or obtaining financing.").

33/ *See, e.g.*, Nam D. Pham, Ph.D., *The Economic Benefits of Commercial GPS Use in the U.S. and the Costs of Potential Disruption*, NDP Consulting, at 1 (June 2011), attached to Comments of Trimble Navigation Limited, IB Docket No. 11-109, IBFS File No. SAT-MOD-20101118-00239 (filed Aug. 1, 2011); *Sustaining GPS for National Security: Hearing Before the Subcomm. on Strategic Forces of the H. Comm. on Armed Services*, 112th Cong. at 3 (Sept. 15, 2011) (written testimony of General William L. Shelton, Commander, Air Force Space Command), *available at* http://armedservices.house.gov/index.cfm/files/serve?File_id=9043b110-61fa-45b9-a8ec6c9f338981cc.

interference levels, shifting the costs and burdens of accommodating such operations to incumbents. The unpredictability of this regime would discourage future investment in spectrum-related enterprises. Even more troubling, a HCTs approach could also encourage parties to make risky investments based on the belief that they could persuade the Commission to continue to raise the HCT, or that they would be able to successfully delay or resist meritorious claims of interference below the HCT.

The existence of hundreds of millions of "decoupled" GNSS receivers will create insurmountable administrative challenges for the Commission, should it pursue RIIA for such devices. GPS devices receive signals directly from satellites. While GPS satellites are subject to extensive FCC regulation, GPS receivers are "decoupled" from FCC spectrum licensing requirements and from any centralized data collection process or mechanism. Unlike mobile carriers that regularly take signal measurements in the ordinary course of their business, there is no central source or obvious mechanism for collecting such data for "decoupled" devices.

The TAC itself acknowledges that application of HCTs may require special consideration for safety-of-life systems and "decoupled" receivers.[34/] GPSIA agrees. GPSIA's previous experience has borne this out, demonstrating that probabilistic methods for determining interference, like HCTs, raise special concerns since they are subject to varying interpretations. Probabilistic models also present difficult issues for "decoupled," non-communications services like GPS which operate below the noise floor and lack a central licensee or carrier that might help implement a HCTs regime. It is highly unlikely that various disjointed parties will agree on

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[34/] RECEIVERS AND SPECTRUM WORKING GROUP, FCC TECHNOLOGICAL ADVISORY COUNCIL, INTERFERENCE LIMITS POLICY: THE USE OF HARM CLAIM THRESHOLDS TO IMPROVE THE INTERFERENCE TOLERANCE OF WIRELESS SYSTEMS 34 (2013), *available at* http://transition.fcc.gov/bureaus/oet/tac/tacdocs/WhitePaperTACInterferenceLimitsv1.0.pdf.

the many assumptions required as inputs to RIIA.[35/] These challenges and difficulties are likely to be magnified when innovation outpaces the standards and assumptions embodied in HCTs. All told, these various issues may make implementation of HCTs administratively taxing, if not impossible.

Millions of devices are and will continue to be in the hands of businesses and consumers, and the need to manage data and complaints from these devices would place a staggering administrative burden on the Commission. Current staff levels at the Commission would be insufficient to handle this burden. In particular, as discussed below, the Commission would also incur additional administrative burdens and legal liabilities in regulating high-risk, high-consequence safety-of life systems through RIIA.

Probabilistic risk analysis has the potential to mask the magnitude of interference to safety-of-life services. The fact that there is a low probability of an event occurring does not guarantee that the event will not take place. It just will not occur very often. Aviation, rail, and maritime accidents are extremely rare. But they are also extremely high impact and result in high economic and human cost.[36/]

Similarly, the TAC's RIIA document makes reference to the Nuclear Regulatory Commission's use of quantitative risk assessment and concludes "that quantitative risk assessment can be applied successfully in an industry where safety-of-life is paramount."[37/] However, in 2011, Fukushima Daiichi – a major accident deemed a 7 on the International

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35/ *See* Comments of the GPS Innovation Alliance, ET Docket No. 13-101 at 19 (filed July 22, 2013).

36/ *See, e.g.*, Letter from F. Michael Swiek, Executive Director, GPS Innovation Alliance, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 12-340, et al. (filed July 13, 2017).

37/ *See* RIIA WHITE PAPER at 11.

Nuclear Events Scale – happened.[38/] The low probability of the right sequence of events stands in contrast with the real-life consequences of the accident. In considering TAC's RIIA recommendations, GPSIA urges the Commission to proceed with extreme caution when considering high-risk, high-consequence safety-of-life services that depend on navigation inputs.

V. IMPROVING INTERFERENCE RESOLUTION

The TAC recommends that the Commission adopt several steps that it believes will improve interference resolution.[39/] In particular, it suggests that the Commission develop a next generation systems architecture in order to adequately address and respond to current interference challenges arising from both transmitting and receiving equipment. While GPSIA appreciates the spirit of the TAC's recommendations, the Commission must not abdicate its responsibility to actively manage the spectrum in favor of an unprecedented one-size-fits all approach that disregards critical differences between technologies and applications. The Commission must remain the ultimate arbiter of interference issues.

The Communications Act charges the Commission with authority over the nation's radiofrequency spectrum and determining what radiofrequency regulations best serve the public interest.[40/] Regulations that address interference protection, unlicensed frequencies, and compliance with international obligations – highlighted by the Public Notice – are at the core of

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38/ *Fukushima Accident*, WORLD NUCLEAR ASSOCIATION (last updated Oct. 2017), http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-accident.aspx ("Before the accident, there was a basic assumption in Japan that the design of nuclear power plants and the safety measures that had been put in place were sufficiently robust to withstand external events of low probability and high consequences.").

39/ INTERFERENCE RESOLUTION WHITE PAPER.

40/ *See* 47 U.S.C. § 151; *see also* 10 U.S.C. § 2281; *U.S. Space-Based Positioning, Navigation, and Timing Policy*, GPS.GOV (Dec. 15, 2004), http://www.gps.gov/policy/docs/2004/; National Space Policy of the United States of America (June 2010), https://obamawhitehouse.archives.gov/sites/default/files/national_space_policy_6-28-10.pdf.

the Commission's regulatory obligations, and they must be retained. While the Commission may consider the input of third-party groups and standards setting organizations, it must not – and indeed may not – abdicate its authority or judgment on these important radiofrequency matters. The Commission itself must consider interference issues because it, rather than external entities, is much better equipped and positioned to make determinations regarding inter-service protection criteria and the impact on the public interest.

Spectrum management is one of the Commission's central functions, and indeed one that is exclusively assigned to the Commission, requiring that the Commission promulgate rules that ensure the ability of disparate services to co-exist. The Commission is uniquely positioned to take into consideration incumbent rights, the value of unlicensed operations, international matters such as harmonization, national policy to protect GPS-based services, and other issues, in order to effectively arbitrate among services to determine appropriate protection levels. Moreover, the Commission has broad statutory obligations to fulfill in pursuit of the public interest,[41/] and it is therefore more appropriate for the Commission, rather than for third parties, to consider long-term planning and goals for technological advancement and spectrum use, and based on those and other factors, determine the technical rules appropriate for different services. Consequently, it is particularly inappropriate for the Commission to rely on external entities to create interservice protection criteria. While interference testing and analysis can be performed by third parties based on objective measurements and well-documented procedures, follow-on determinations incorporating public interest considerations can only be reached by the Commission.

41/ *See, e.g.*, 47 U.S.C. §§ 151, 157, 309.

VI. CONCLUSIONS

GPSIA appreciates the effort that the TAC has undertaken to help the Commission manage spectrum. Missing from those efforts to date is a recognition of the critical difference between communications and navigation systems and the internationally established criteria – a 1 dB decrease in C/N_0 – as an interference protection criterion which ensures that a harmful interference level is prevented in the first place so that systems operating in the same or adjacent bands do not interfere with one another.[42/] When the TAC refines its recommendations to the Commission based on the comments received in response to the recent *Public Notice*, it should incorporate these points, which are critical to the continued robust position that GPS-enabled technologies enjoy in our national infrastructure. Doing so is consistent with the Commission's statutory obligation to manage spectrum, rather than abdicating that role in favor of an approach that ignores differences between technologies and applications.

Respectfully Submitted,

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[42/] *See Background Paper on Use of a 1-dB Decrease in C/N_0 as GPS Interference Protection Criterion*, UNITED STATES AIR FORCE, at Section 8(a), https://www.gps.gov/spectrum/ABC/1dB-background-paper.pdf (last accessed Jan. 30, 2018); STEPHEN MACKEY, HADI WASSAF, & KAREN VAN DYKE, DOT GPS ADJACENT BAND COMPATIBILITY ASSESSMENT TEST RESULTS (2017), https://pdfs.semanticscholar.org/7468/1f17152e5953cfeeb54ff7def4e8496e897a.pdf.