post to *https://www.regulations.gov* will include any personal information you have provided. For more about privacy and submissions to the docket in response to this document, see DHS's eRulemaking System of Records notice (85 FR 14226, March 11, 2020).

List of Subjects in 33 CFR Part 165

Harbors, Marine safety, Navigation (water), Reporting and recordkeeping requirements, Security measures, Waterways.

For the reasons discussed in the preamble, the Coast Guard is proposing to amend 33 CFR part 165 as follows:

PART 165—SAFETY OF LIFE ON NAVIGABLE WATERS

■ 1. The authority citation for part 165 continues to read as follows:

Authority: 46 U.S.C. 70034, 70051; 33 CFR 1.05–1, 6.04–1, 6.04–6, and 160.5; Department of Homeland Security Delegation No. 00170.1, Revision No. 01.2.

■ 2. Add § 165.T09–0307 to read as follows:

§ 165.T09–0307 Safety Zone; North Coast Harbor, Lake Erie, Cleveland, OH.

(a) *Location.* All navigable waters of North Coast Harbor into the East Basin Channel.

(b) *Enforcement period.* This section will be enforced from 7 a.m. through 10 a.m. on August 20, 2022.

(c) *Definitions.* ''Official Patrol Vessel'' means a Coast Guard Patrol Commander, including a Coast Guard coxswain, petty officer, or other officer operating a Coast Guard vessel and a Federal, State, and local officer designated by or assisting the Captain of the Port Sector Buffalo (COTP) in the enforcement of the regulations in this section. ''Participant'' means all persons and vessels attending the event.

(d) *Regulations.* (1) The Coast Guard may patrol the event area under the direction of a designated Coast Guard Patrol Commander. The Patrol Commander may be contacted on Channel 16 VHF–FM (156.8 MHz) by the call sign ''PATCOM.''

(2) All persons and vessels not registered with the sponsor as participants or official patrol vessels are considered spectators. The ''official patrol vessels'' consist of any Coast Guard, state or local law enforcement and sponsor provided vessels designated or assigned by the Captain of the Port Sector Buffalo, to patrol the event.

(3) Spectator vessels desiring to transit the regulated area may do so only with prior approval of the Patrol Commander and when so directed by that officer and will be operated at a no wake speed in a manner which will not endanger participants in the event or any other craft.

(4) No spectator shall anchor, block, loiter, or impede the through transit of official patrol vessels in the area specified in paragraph (a) of this section during the effective dates and times specified in paragraph (b) of this section, unless cleared for entry by or through an official patrol vessel.

(5) The Patrol Commander may forbid and control the movement of all vessels in the regulated area specified in paragraph (a) of this section. When hailed or signaled by an official patrol vessel, a vessel shall come to an immediate stop and comply with the directions given. Failure to do so may result in expulsion from the area, citation for failure to comply, or both.

(6) Any spectator vessel may anchor outside the regulated areas specified in this section, but may not anchor in, block, or loiter in a navigable channel.

(7) The Patrol Commander may terminate the event or the operation of any vessel at any time it is deemed necessary for the protection of life or property.

(8) The Patrol Commander will terminate enforcement of the special regulations at the conclusion of the event.

Dated: May 2, 2022.

L.M. Littlejohn,

Captain, U.S. Coast Guard, Captain of the Port Buffalo.

[FR Doc. 2022–10172 Filed 5–12–22; 8:45 am]

BILLING CODE 9110–04–P

FEDERAL COMMUNICATIONS COMMISSION

47 CFR Parts 15, 20, 22, 24, 25, 27, 30, 73, 74, 76, 78, 80, 87, 90, 95, 96, and 101

[ET Docket No. 22–137; FCC 22–29 FRS 85531]

Promoting Efficient Use of Spectrum Through Improved Receiver Interference Immunity Performance

AGENCY: Federal Communications Commission.

ACTION: Proposed rule.

SUMMARY: This document invites comments from all stakeholders in connection with the development of an up-to-date record on the role of receivers in spectrum management and how the Federal Communications Commission (Commission or FCC) might best promote improvements in receiver interference immunity performance that would serve the public interest. The Commission seeks to build upon the progress, including technological advances, in recent years that has enabled better receiver interference immunity performance, and the Commission seeks comment on where those efforts and advances have been most successful. The Commission also seeks to learn lessons from recent Commission proceedings in which receiver performance concerns have been prominent, to better inform the Commission as it considers how to ensure valuable and innovative services are able to thrive across the frequency range.

DATES: Comments are due on or before June 27, 2022, and reply comments are due on or before July 27, 2022.

FOR FURTHER INFORMATION CONTACT: Paul Murray of the Office of Engineering and Technology, at *paul.murray@fcc.gov* or (202) 418–0688, or Michael Ha of the Office of Engineering and Technology, at *michael.ha@fcc.gov* or (202) 418–2099.

SUPPLEMENTARY INFORMATION: This is a summary of a document in, ET Docket No. 22–137, FCC 22–29, released April 21, 2022 (Notice of Inquiry). The full text of the document is available for inspection and copying during normal business hours in the FCC Reference Center (Room CY–A257), 45 L Street NE, Washington, DC 20554. The full text may also be downloaded at: *https://www.fcc.gov/document/fcc-launches-proceeding-promoting-receiver-performance-0.* People with Disabilities: To request materials in accessible formats for people with disabilities (braille, large print, electronic files, audio format), send an email to *fcc504@fcc.gov* or call the Consumer & Governmental Affairs Bureau at (202) 418–0530 (voice), (202) 418–0432 (tty).

Synopsis

In this document, the Commission takes a fresh look at the role of receiver performance in its spectrum management responsibilities, with the goal of facilitating new opportunities for use of its nation's spectrum resources. Forward-facing spectrum management necessitates that the Commission continuously promote more efficient spectrum use to enable the introduction of valuable new wireless services that benefit the American people. As spectrum use across the radio frequencies (RF) becomes more intensive, and services are packed more closely together, Commission spectrum management policies must consider potential efficiencies across all aspects

of wireless systems, not just transmitters but receivers as well. While the Commission has typically focused its rules on the transmitter side of radio systems, as several recent Commission proceedings have underscored, receivers and receiver interference immunity performance play an increasingly critical role in enabling more efficient spectrum use.

The Commission seeks through this document to develop an up-to-date record on the role of receivers in spectrum management and how it might best promote improvements in receiver interference immunity performance that would serve the public interest. The Commission seeks to build upon the progress, including technological advances, in recent years that has enabled better receiver interference immunity performance, and the Commission seeks comment on where those efforts and advances have been most successful. The Commission also seeks to learn lessons from recent Commission proceedings in which receiver performance concerns have been prominent, to better inform the Commission as it considers how to ensure valuable and innovative services are able to thrive across the frequency range. To further assist the Commission's efforts, it also seeks to consider anew the efforts, reports, studies, and recommendations, including several of the Commission's Technological Advisory Council (TAC) White Papers, that have been proffered in recent years regarding the kinds of actions that the Commission should consider.

In sum, the Commission begins the process of developing potential pathways for improvements in receiver performance, where and as appropriate, that will aid in making spectrum management more effective and provide more benefits to the American public. As the Commission discusses below, it recognizes that a variety of approaches may be appropriate, whether through industry-led voluntary measures, Commission policy and guidance, or rule requirements where other approaches would be insufficient. In this important first step the Commission seeks to compile a comprehensive record on the various issues that the Commission should consider, inviting broad comment from all stakeholders as the Commission considers these issues. The Commission looks forward to reviewing the record that develops from this Inquiry to inform us regarding possible next steps that the Commission may take in the future to promote efficient spectrum management in the public interest.

Background

In 2003, the Commission adopted a Notice of Inquiry (NOI) to begin ''consideration of incorporating receiver interference immunity performance specifications into its spectrum policy on a broader basis'' (68 FR 23677 (May 5, 2003)) (*NOI on Receiver Performance Specifications*). The Commission noted that incorporating receiver performance specifications could promote more efficient spectrum use and create opportunities for new and additional use of radio communications services by the American public. The Commission indicated that consideration of receiver interference performance specifications could be in the form of incentives, guidelines, or regulatory requirements (or a combination of these) in particular frequency bands, services or across bands and services.

The 2003 NOI sought information, comment, and research concerning the immunity performance and interference tolerance of existing receivers, the possibilities for improving the level of receiver immunity in the various radio services, and potential impacts of receiver standards on innovation and the marketplace. In particular, the Commission sought comment on the following issues—receiver performance parameters (*e.g.,* selectivity, sensitivity, dynamic range, automatic RF gain control, shielding, modulation method, and signal processing); the current RF environment and receiver interference immunity performance; various approaches that the Commission should consider for incorporating receiver interference immunity performance guidelines into spectrum policy (including voluntary industry standards, guidelines promulgated by the Commission, and mandatory standards); receiver performance in various radio services; the potential impact of receiver performance specification on innovation and the marketplace; and the treatment of existing receivers and the transition pathways to improved receivers.

Several commenters responding to the 2003 NOI supported the Commission's further exploring interference immunity performance standards and agreed that improved receiver performance can help improve spectrum efficiency and ensure greater access to spectrum for all users; they differed, however, regarding the appropriate approach(es) and how to implement them with respect to particular bands. In 2007, the Commission terminated the proceeding ''without prejudice to its substantive merits.'' The Commission stated that, with the passage of time, the record had become outdated and that, to the extent that receiver interference immunity performance specifications are desirable, they could be addressed in proceedings that are frequency band or service specific.

Commission Rules on Receiver Performance Requirements

As a general matter, the Commission's regulation of transmitters has at least implicitly provided for an RF environment that affects receiver performance insofar as the technical characteristics of receivers are expected to process those transmissions to successfully establish communications. The overall objective of that regulation has been to provide, through limits on power levels, in-band and out-of-band emission limits, operational requirements regarding antennas, etc., an RF environment that facilitates those communications as much as possible. In some limited circumstances, the Commission has more directly addressed regulated receiver performance, both through performance standards and performance incentives, only in limited circumstances, such as in the examples that follow.

800 MHz Band Public Safety Re-banding. In the 800 MHz public safety re-banding proceeding, minimum receiver performance was a major consideration when establishing whether a licensee operating in the band could claim entitlement to protection against ''unacceptable interference.'' Specifically, the Commission established a bright-line test for determining if a licensee is fully eligible to claim protection against ''unacceptable interference'' based on, among other factors, the characteristics of the receiver being employed by the licensee seeking protection.

900 MHz Band. The Commission adopted for the 900 MHz band interference criteria similar to those established for the 800 MHz band. Like in the 800 MHz band, the Commission established a definition of ''unacceptable interference'' to 900 MHz narrowband licensees from 900 MHz broadband licensees and established technical parameters including a receiver intermodulation rejection ratio, adjacent channel rejection ratio, and reference sensitivity.

Digital Television. Improved receiver performance was a major consideration as the Commission prepared for the digital television (DTV) transition. Prior to that transition, the Commission adopted a series of decisions intended to help address issues regarding the conversion of analog TV to digital TV, a transition that was finalized in 2009. In planning for the DTV transition, the

Commission had anticipated the need for certain minimal receiver specifications. Several interested parties had recognized that voluntary transition might not be sufficient, and the Commission agreed, mandating receiver specifications for TV broadcast receivers in 2002 that would go into effect after a specified phase-in period to ensure a smooth transition.

Part 96 Citizens Broadband Radio Service. The Commission adopted rules in the 3.55–3.7 GHz Band governing reception limits for Citizens Broadband Radio Service users and incumbents that established ''acceptable levels'' of in-band and adjacent band interference for operations. These limits apply to Priority Access Licensees, incumbent Fixed Satellite Service (FSS) earth stations in the 3.6–3.7 GHz band, and adjacent band FSS earth stations used for telemetry, tracking, and control. The Commission also established received signal strength limits for Citizens Broadband Service Devices (CBSDs) and required Spectrum Access System administrators to manage transmissions to ensure that aggregate signal strength remains below a fixed threshold between geographically adjacent service areas held by different licensees.

Part 27 Broadband Radio Service/ Educational Broadband Service. The Commission established rules that specify the minimum signal level below which Broadband Radio Service/ Educational Broadband Service base station receivers in the 2496–2690 MHz band do not receive interference protection from co-channel base station transmitters not exceeding the height benchmark.

Part 27 3.7 GHz Service. When authorizing the 3.7–3.98 GHz Band for flexible use, the Commission adopted rules to protect incumbent FSS earth stations from out of band emissions and blocking interference; these rules that require that transmitters are separated from FSS earth station receivers by 20 megahertz and meet both in-band and out-of-band power-flux density (PFD) limits as measured at each incumbent FSS earth station antenna and established specific protection criteria for earth stations used for telemetry, tracking, and control. The Commission also adopted rules that required passband filters to be installed on incumbent FSS earth station antennas and established a transition process to, in part, ensure that such filters are acquired and installed at each antenna.

Part 80 Maritime Service. The Commission adopted several technical requirements, such as sensitivity and/or stability requirements, for certain receivers in the Maritime Services. It also has incorporated by reference standards for Global Maritime Distress and Safety System operations which include receiver operational and performance requirements.

Part 87 Aviation Service. To maintain the accuracy of critical location information for applications such as aircraft precision landings, part 87 Aviation Service rules specify performance requirements for differential global positioning system (GPS) receivers (in the presence of undesired VHF–FM broadcast signals) relied upon for aviation safety purposes.

Part 95 Personal Radio Services. To ensure that life-saving Personal Locating Beacons and Maritime Survivor Locating Beacons operate properly and do not further endanger those in distress and/or rescue personnel, these devices must meet technical standards incorporated by reference in the rules which include receiver operational and performance standards.

Recent Proceedings

In several recent Commission proceedings, the receiver interference immunity performance associated with incumbent services operating in spectral proximity to new users or services has been a major consideration. In these cases, the ability of incumbent service receivers to reject signals outside their intended band has been directly relevant to the timing and scope of the introduction of new services.

For example, in both the *Ligado* and the *3.7 GHz Band* proceedings, the Commission adopted operating conditions and rules to enable the introduction of new operations into frequency bands with various incumbent users operating under different service allocations in the same band, adjacent band, or other spectrally proximate frequency bands. Although the factual circumstances of these two proceedings differ, both illustrate the challenges that systems face to co-exist and successfully operate when the spectral environment changes especially when incumbent systems may have been designed based on different assumptions about the RF environment in adjacent bands or other nearby frequency bands. These proceedings demonstrate that having accurate and timely information about receiver characteristics can be helpful in the Commission's analysis of potential harmful interference concerns and also highlight several other spectrum management issues that can arise with respect to receiver interference immunity performance, including receiver interference susceptibility, receiver selectivity, the impact of technological advancements (including filtering), and legacy devices.

Technological Advisory Council (TAC) White Papers and Workshops

In recent years, the Commission's Technological Advisory Council (TAC) also has been engaged in examining various technical issues concerning receiver performance in several of the White Papers that the TAC has issued. In addition, the TAC has made several recommendations for the Commission's consideration on potential ways to promote the development and deployment of receivers that are more resilient to interference and could enable more efficient use of the Nation's spectrum resources.

White Paper on Spectrum Efficiency Metrics. In 2011, the Commission's TAC issued a White Paper on ''spectrum efficiency metrics,'' which it viewed as an important factor in the Commission's spectrum management decisions. The TAC took an ''integrated systems approach'' in its evaluation of spectrum efficiency metrics, and noted that every component of a radio based communications system involved with either the transmission and/or reception of a signal has to be considered as part of efficiency. The TAC recognized a close relationship between spectrum efficiency and receiver standards/ guidelines or performance.

White Papers on Interference Limits Policy and Harm Claim Thresholds. In 2013, the TAC issued a *White Paper on Interference Limits Policy* in which it explored potential policy—an ''interference limits policy,'' including harm claim thresholds—that it believed could promote more transparent consideration of receivers in spectrum management and promote better receiver performance. The TAC believed that the Commission could increase service density, reduce regulatory risk, and encourage investment with adoption of rules that make clear in which situations receivers and transmitters each will have the responsibility for mitigating any harmful interference, and doing so up-front rather than after lengthy post-dispute proceedings. This approach would state explicitly when receivers may claim harmful interference as a necessary complement to existing transmitter regulation that could facilitate more intensive frequency use by providing more clarity about the baseline regulatory and radio interference context going forward. In 2014, the TAC followed with issuing its *White Paper on Harm Claim Thresholds,* which provided additional discussion on an interference limits

policy focusing on harm claim threshold approaches.

White Paper on Risk-informed Interference Assessment. In 2015, the TAC issued its *White Paper on Risk-informed Interference Assessment.* The TAC recommended that the Commission adopt risk-informed interference assessment and statistical service rules more widely to help improve its spectrum management decision-making. As risk-informed interference assessment would consider likelihood/consequence combinations for potential interference hazard scenarios involving transmitters and receivers; this tool could serve to complement a more static ''worst case'' analysis that considers the single scenario with the most severe consequence regardless of its likelihood.

White Paper on Basic Principles for Assessing Compatibility of New Spectrum Allocations. In 2015, the TAC released another *White Paper on Basic Principles* for assessing compatibility of new spectrum allocations. It believed that a set of basic principles could be helpful for *all* involved parties to consider and could serve to establish clearer expectations of incumbent services as well as new services entering the spectrum. Several of the basic principles directly related to expectations regarding both transmitters and receivers. As contemplated, these principles sought to promote ''good neighbor policies'' among spectrum users that more effectively enable users to ''get along.''

Commission workshops. In 2012, as part of the Commission's efforts to develop more effective spectrum management approaches that promote greater spectrum efficiency, the Commission's Office of Engineering and Technology, in conjunction with the Wireless Telecommunications Bureau and the Office of Strategic Planning, hosted a workshop on ''Spectrum Efficiency and Receiver Performance.'' In the workshop, the Offices and Bureaus pointed out that receiver performance has historically arisen in the context of conflicts between legacy stakeholders and new entrants, where deployments of new technologies and services threatens to adversely impact an incumbent or place restrictions on the new entrant. In 2014, the Commission's Office of Engineering and Technology (OET), in conjunction with the International Bureau (IB), Public Safety and Homeland Security Bureau (PSHSB), and Wireless Telecommunications Bureau (WTB), hosted another workshop, this one on ''GPS Protection and Receiver Performance.

Other Relevant Studies, Analyses, and Memoranda

NTIA Report on Receiver Standards. In 2003, the same year that the Commission issued its *NOI on Receiver Performance Specifications,* the National Telecommunications and Information Administration (NTIA) issued a report on ''Receiver Spectrum Standards'' as part of its effort to explore promoting more interference-robust receivers. NTIA suggested several reasons why interference and efficiency problems were becoming more important. These included the dramatic increase in spectrum use, the introduction of new services and systems without standards needed for electromagnetic compatibility, design tradeoffs that favored inexpensive radio equipment rather than good performance, reduction in available guard bands, equipment manufacturers' lack of knowledge of characteristics of equipment operating in the same or adjacent bands, and increased receiver front-end bandwidth of receivers.

CSMAC Report on Fostering Spectrum Sharing and Improving Spectrum Efficiency. In 2010, the Commerce Spectrum Management Advisory Committee (CSMAC) issued a report that among other things underscored the importance of receivers as tools in achieving greater spectrum efficiency. CSMAC recommended developing incentives for promoting better receivers and transmitters, promoting awareness of interference characteristics of receivers and transmitters, improving filter performance, promoting certainty and appropriate consideration of legacy devices, and taking technological advances into account regarding legacy equipment.

Kwerel and Williams Paper on ''Forward Looking Interference Regulation.'' In 2011, Evan Kwerel and John Williams published a paper proposing that the Commission should provide better incentives to build more interference-robust systems in future allocations by moving away from a general interference protection model in spectrum management that often provides incumbent users protection against any interference resulting from subsequent rule changes. The paper asserted that the adjacent band interference protection for incumbents should not be static and recommended that incumbents be incentivized to ''self-protect'' their wireless operations (including their receivers) against interference from adjacent bands (*e.g.,* assuming that the adjacent band would be used for flexible use). The paper also noted certain market failures (*e.g.,* lack of clarity regarding rights, holdout problems, transaction costs) that prevented efficient resolution of interference problems between incumbent users and new licensees through negotiation.

Silicon Flatirons Reports—on Efficient Interference Management and on Receivers. In 2012 and 2013, the Silicon Flatirons Center issued two reports on spectrum management and receiver performance drawn from its roundtable conferences comprised of government, industry, and policy experts. The 2012 report on ''Efficient Interference Management: Regulation, Receivers, and Right Enforcement'' noted that receiver performance dramatically affects the coexistence of adjacent services, and further noted that while transmitters are required to control out-of-band and spurious emissions to minimize interference, receivers are not generally required to minimize interference from such emissions. The report identified several recurring problems that should be addressed (*e.g.,* incumbents not accounting for a changing RF environment, ''poor knowledge transfer'' among all of the affected parties regarding receiver interference problems that could enable potential resolution), and stated that it would be helpful if regulators could better anticipate the needs at band edges and provide proper notice to affected parties on the need for better receivers and that phase-in of any receiver regulation would be important. The second Silicon Flatirons report, ''Receivers, Interference, and Regulatory Options,'' also identified several problems that have made it difficult to improve receiver performance, including: Externalities (since the party who would bear the cost of improving receivers is not the party who benefits); ''asymmetric information'' (between incumbent users and adjacent band users seeking to mitigate interference but lacking information needed to effectively reduce interference); general lack of information for some of the parties affected; the need to understand costs and benefits (which could help enable creation of an incentive structure to improve receiver performance); and the need for more clarity about the RF environment. That report recommended improving transparency among operators and consumers creating more incentives to build more robust receivers (*e.g.,* through issuance of a policy statement). Several on the panel also supported use of multi-stakeholder groups to develop appropriate technical solutions. Finally, the report

recommended appropriate notice to stakeholders of any proposed changes and development of a transition plan.

PCAST Report on Spectrum Sharing. In 2012, the President's Council of Advisors on Science and Technology (PCAST) issued a report that dedicated significant discussion to the important role of receivers and receiver performance for spectrum management and promoting more efficient use of spectrum. In particular, given that receiver characteristics can be a significant factor in limiting operations in adjacent spectrum bands, the report underscored the importance of knowing receiver characteristics for spectrum management among operations in adjacent bands. PCAST also made several observations and recommendations regarding receivers. It believed that different types of receivers may require different approaches to receiver management. It also supported consideration of the harm claims threshold approach for receiver interference limits.

GAO Report on Receiver Performance. In 2013, the Government Accountability Office (GAO) issued its report, observed that while the Commission and NTIA have historically focused on transmitters, receivers also can play an important role in better spectrum management. GAO identified challenges related to improving receiver performance, including the lack of coordination across industries when developing voluntary standards, the lack of incentives for manufacturers or spectrum users to incur costs associated with using more robust receivers, and the difficulty of accommodating a changing spectrum environment. GAO also identified various options for consideration, including developing voluntary industry standards, creating a ''safe harbor'' in which compliance with industry standards would be a pre-requisite to claim harmful interference; mandatory standards, interference limits, and gathering additional information on spectrum use and the characteristics of systems (which it thought on the one hand could enable more informed decision-making while on the other raise concerns about disclosure of proprietary or classified information).

Presidential Memorandum on Wireless Innovation. In 2013, President Obama issued a Presidential memorandum on ''Wireless Innovation,'' which included a section on receiver performance that encouraged the Commission, in consultation with NTIA, where appropriate, the industry, and other stakeholders, to develop to the fullest extent of its legal authority a program of performance criteria, ratings, and other measures, including standards, to encourage the design, manufacture, and sale of radio receivers such that emission levels resulting from reasonable use of adjacent spectrum will not endanger the functioning of the receiver or seriously degrade, obstruct, or repeatedly interrupt the operations of the receiver.

International developments. Finally, the Commission note that international regulators and intergovernmental organizations also have discussed the importance of ensuring that receivers are appropriately designed in order to promote more efficient use of spectrum. For example, the International Telecommunication Union (ITU) ''Radio Regulations'' include several provisions that concern ''technical characteristics of stations'' associated with transmitter and receiver equipment and performance with respect to each other and in the context of promoting more efficient and effective use of spectrum, including Radio Regulations (RR) Nos. 3.3, 3.9, 3.11, 3.12, and 3.13. In 2014, the European Union (EU) issued Radio Equipment Directive 2014/53/EU, which recognized the important role of transmitter and receiver radio equipment in spectrum management. Among the Radio Equipment Directive ''Essential Requirements'' is that radio equipment should be constructed so as to ensure ''an adequate level of electromagnetic compatibility'' and in a manner that ''both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference.'' Additionally, the United Kingdom Ofcom's 2021 spectrum management strategy statement states that it is essential to encourage spectrum users to be more resilient to interference, and that operators should not generally expect Ofcom to take action on interference if it is a result of the poor performance of receivers or wider systems.

Discussion

The Commission begins by discussing the critical role that receiver performance plays with regard to spectrum management and enabling more efficient use of spectrum. The Commission then inquires about a wide range of approaches that the Commission might consider to promote more efficient use of spectrum that will enable greater access to the Nation's spectrum resources for new services that will benefit Americans.

The Critical Role of Receiver Performance in Spectrum Management

The Commission issues this document with the goal of considering various approaches that will enable us to reorient its spectrum management lens—from focusing primarily on the transmitter side of wireless networks to focusing on both the transmitter *and* receiver sides of wireless systems. Both are vital to the innovative and efficient use of spectrum. While the Commission has long relied on rules establishing particular transmitter requirements to promote spectrum efficiency and more intensive use, receiver performance also can significantly affect the Commission's ability to introduce new services in the same or nearby frequencies. In particular, receivers without sufficient interference immunity performance can diminish opportunities for innovative spectrum uses that drive economic growth, competition, security, and innovation. They can put constraints on what is possible in the evolving wireless world.

Considering additional ways to promote more efficient use of spectrum by focusing on the role of both transmitters *and* receivers is even more important today than it was when the Commission initiated its earlier NOI on receiver performance in 2003. Continuous growth of and high demand for spectrum-based services makes this examination of receiver performance critical to more effective Commission spectrum management going forward. Greenfield spectrum—open and cleared for use—is hard to find in the current spectral environment. To make spectrum available for new and expanded services, existing spectrum users are packed into a more congested environment, as transmitters and receivers increasingly are situated in closer spectral and geographic proximity. In this congested environment, it is challenging to meet the demands for spectrum availability by simply relying on spectrum management tools used in the past. As the RF environment continues to change, receiver performance necessarily assumes greater importance in enabling more efficient spectrum use and effective spectrum management.

In this document, the Commission inquires about the role of receivers as part of its broader exploration of policy tools that can harness new technologies and promote expanded and efficient spectrum use. The Commission seeks to develop a record on receiver performance across the RF spectrum, and on how the Commission might consider options that can promote more

efficient spectrum use, where and as appropriate, that can best serve the public interest. The Commission invites broad comment on the various approaches and questions posed in this document. The Commission encourages commenters to focus on risk-based assessments and science-driven policy. As discussed below, the Commission recognizes that a variety of approaches may be appropriate, including industry-led voluntary measures, clearer Commission policy and guidance, and, where other approaches may be insufficient, requiring specified levels of performance. Different approaches may be appropriate depending on the particular circumstances, including the types of services involved, and the Commission invites comment to help guide the Commission's considerations. The Commission anticipates that commenters will discuss a range of options for possible industry and government actions, including those described below, as well as how best to implement any new policies in a manner that establishes clearer interference-related rights and responsibilities among spectrum users that can promote more efficient spectrum use while also driving innovation and serving the public interest.

Considerations for Promoting Receiver Interference Immunity Performance

As set forth below, the Commission inquires about a number of different considerations as the Commission evaluates approaches for promoting improved receiver interference immunity performance. The Commission invites comment on each of these approaches while also recognizing that some approaches may be more effective than others for addressing receiver performance concerns in particular situations, and that some mix of approaches may best serve the public interest.

Receiver Performance Parameters

Inquiring about receiver performance parameters, or how they, along with transmitter parameters define the RF environment, is essential to understanding what actions, if any, the Commission should consider taking. In the 2003 *NOI on Receiver Performance Specifications,* the Commission similarly sought comment on what receiver performance parameters the Commission should consider. As the *NOI on Receiver Performance Specifications* recognized, a radio receiver's immunity to interference is dependent on a number of factors in its technical design and, in addition, the characteristics of the signals it receives; these factors may be closely related and interdependent, and a receiver's performance in one factor may often affect its performance in others. The NOI then identified several parameters—including selectivity, sensitivity, dynamic range, automatic RF gain control, shielding, modulation method, and signal processing—and requested comment and information on these or any other factors and how they are related that should be considered.

Subsequent efforts identified additional receiver parameters and engaged in further discussion on how such parameters could or should be considered by the Commission as it evaluates steps that it might take to promote receiver performance. These include, for instance, discussion in TAC White Papers, including the *White Paper on Interference Limits Policy,* the *White Paper on Harm Claim Thresholds,* and the *White Paper on Risk-informed Interference Assessment,* as well as the *PCAST Report.* CSMAC also emphasized the importance of developing more information on receiver filter performance, including working with the filter technology community on improving filter performance.

Discussion. In this document, the Commission seeks information on receiver performance parameters that the Commission should consider, including those identified in the Commission's earlier NOI or others that commenters consider relevant, as the Commission continues to examine whether the Commission should consider ways to promote receiver performance where appropriate. In particular, the Commission seeks to update and refresh the information presented in any earlier Commission proceeding or studies identified above, as well as any other relevant information (studies, analyses, reports, etc.) or past experience that could be useful as the Commission considers receiver parameters and receiver performance matters.

As the Commission previously noted, interference immunity is dependent on several factors in the receiver's technical design as well as the characteristics of the signal it receives. In considering approaches to advance receiver performance in ways that take receiver performance parameters into greater consideration, what specific parameters (*e.g.,* selectivity, sensitivity, dynamic range, automatic RF gain control, shielding, modulation method, signal processing) should be considered? The Commission asks that commenters identify the various parameters (including but not limited to those listed here) as well as their typical ranges, that the Commission should consider.

The Commission invites comment on whether there are specific receiver performance parameters that are more critical for allowing introduction of new services in the adjacent or neighboring bands without causing unacceptable interference. Are there any special hardware designs, software methodologies, or new technologies available that would significantly enhance receiver immunity performance? Are there techniques that can be used to improve these receiver performance parameters? How are various parameters interrelated? Are there factors that could or should be considered as a group and not independently due to their cross interactions or relationships with other factors? For example, to what extent does a receiver's selectivity and sensitivity affect its dynamic range? What are the various trade-offs that must be considered when optimizing these parameters when designing a receiver? Can receiver interference immunity parameters be ranked or rated in accordance with their level of importance to performance? If the Commission were to take action, what performance levels should be associated with each parameter? Should requirements differ by service? If so, how should they differ for various services? Should performance levels be required to change over time (*i.e.,* require increased interference tolerance on a specified timescale or based on some triggering event)? Commenters advocating such an approach should provide details as to which parameters should change and over what timeframe or what the triggering events should be. What procedures or criteria should be used to determine how to trade off the level of receiver performance with the practical issues of cost and implementation?

The Commission seeks comment on any recent technical advancements in receiver design that the Commission should consider. What is the state of the art currently and what advances are anticipated? Are there advancements that have made receivers more resilient or susceptible to interference? If so, the Commission requests comments on changes in design that improved or degraded interference immunity. What specific receiver parameters were affected? Are there organizations or industries that are particularly helpful in developing such technical advancements? What current or planned research projects, either industry or academia based, are focused on receiver

improvements? How can these organizations and projects help inform the Commission as it seeks to identify receiver parameters which, if changed, would lead to the greatest improvement in receiver performance? Is there any ongoing research related to how receiver design could affect or influence regulatory and policy issues and various approaches that the Commission could consider during rulemaking proceedings? Would it be appropriate or feasible for industry stakeholders to maintain a library of specifications, best practices, and trends of receiver interference immunity performance levels?

The Commission requests comment on how receiver performance factors are related to frequency and operating power, and are these factors are influenced by the nature of the RF environment (*e.g.,* how does anticipate in-band and out-of-band power affect receiver performance and influence design choices)? To what extent, and in what way, are certain factors that affect interference immunity relatively more important than others across different types of receivers used in different radio services or across devices that receive signals transmitted using different methods of modulation?

In identifying the various receiver parameters on which the Commission or industry should focus, the Commission notes that there must be standard techniques to evaluate receivers to ensure that they meet any voluntary or required regulatory (including mandatory) benchmarks. The Commission further notes that unlike transmitter characteristics, many receiver parameters are inherently difficult to measure. The Commission seeks information on how receiver performance parameters can be measured, validated, and rated. Is there a subset of receiver performance parameters that can be easily measured and that also provide a reasonable characterization of receiver performance? Are there any industry standards for these types of measurements, created by standardization bodies such as the American National Standards Institute (ANSI), Institute of Electrical and Electronic Engineers (IEEE), 3rd Generation Partnership Project (3GPP), or European Telecommunications Standards Institute (ETSI) that could be helpful as the Commission considers various approaches for promoting receiver performance?

The RF Environment

Understanding the RF environment in which radio services operate, both today and as anticipated in the future, provides important context for the Commission's considerations regarding how best to understand options that could promote better receiver interference immunity performance as part of improved spectrum management. The Commission seeks comment on the RF environment and how it should be factored into consideration.

In the 2003 NOI, the Commission noted that ''existing receivers are, for the most part, built to provide interference immunity as determined necessary by their designer/manufacturer to provide satisfactory service'' which has ''resulted a wide range of immunity performance across products used within the same services and across services.'' Accordingly, the Commission sought comment and information on the interference immunity characteristics of receivers used in various radio services and how receivers performed in those services; as part of its inquiry, it requested information about how many units were at that time in service and about the expected service life of the receivers in various services. It also inquired about different receiver specifications that should be considered depending on the environment in which a receiver operates, or whether instead there should be a ''generic'' environment in which all receivers should be expected to perform adequately.

Several studies and recommendations have emphasized the importance of the Commission and spectrum users to have knowledge of the characteristics of both transmitters and receivers in order to promote more efficient spectrum management. The TAC *White Paper on Basic Principles for Assessing Compatibility of New Spectrum Allocations,* for instance, included a principle that radio services would be ''expected to disclose the relevant standards, guidelines, and operating characteristics of their systems if they expect protection from harmful interference. Another report identified the need for more clarity about the RF environment, which could help inform operators about the type of systems they need to deploy; it also pointed out that not knowing system characteristics created a problem of ''asymmetric information'' insofar as the interference protection enjoyed by a receiving system in one band affects the ability of an adjacent service provider to operate, but that service provider usually does not have all the information needed to make choices that will reduce interference). That report also called for improving transparency for operators, including the sharing of more information on the characteristics of their neighbors' adjacent operations, establishing a device performance registry, and otherwise incentivizing operators to divulge helpful information.

The CSMAC and PCAST reports also discussed the importance of having more information on receiver characteristics. CSMAC believed that new services acquiring or accessing spectrum should be made aware of the interference characteristics of receiving and transmitting equipment operating on frequencies that will be shared or used in adjacent bands. PCAST noted that, given that receiver characteristics can be a significant factor in limiting operations in adjacent spectrum bands, the report underscored the importance of knowing receiver characteristics for spectrum management among operations in adjacent bands. Further, GAO recognized that one option for helping improve spectrum management and decision-making would be for the Commission to gather more information on spectrum use and the characteristics of the systems, including receivers, although GAO thought that this would raise concerns about disclosure of proprietary or classified information.

Finally, recent Commission proceedings have underscored the importance of having better information on receiver characteristics as the Commission exercises its spectrum management responsibilities. This information could enable the Commission to provide greater access to spectrum for new services, promote more efficient use of spectrum, and find ways to better understand the nature and extent of potential interference concerns that may arise with respect to the introduction of new services. It also could enable consideration of pathways to address legacy receivers that may raise particular concerns (*e.g.,* identifying, modifying, repairing, replacing through transitions).

The Commission requests comment on the current RF environment in which various services operate. What is the impact of that environment on the ability for adjacent and nearby operations? Have interference concerns been addressed effectively or ineffectively with regard to adjacent band services (*e.g.,* use of guard bands, technical rules, etc.), or are there other relevant considerations regarding the current RF environment that can inform its consideration in the proceeding?

As the Commission noted in the 2003 NOI, the receiver interference environment and demands placed on receiver performance have often been dependent on the specific type of

service provided on neighboring frequency bands. In that NOI, it sought comment on various operational environments and characteristics of the different types of services at that time (nearly 20 years ago)—including satellite, public safety, mobile, fixed, and broadcast services—as they affected minimum receiver performance needs. It also noted that the types of operations and services occupying neighboring frequency bands often are a significant factor in the environment in which a receiver operates, and the Commission sought information on receiver performance issues of specific types of service and operations relating to both the in-band and out-of-band environments.

The Commission again seeks comment on the current RF environment with respect to particular services—including various mobile services (terrestrial, aeronautical, satellite, maritime), fixed services (point-to-point microwave, point-to-multipoint, satellite), public safety services, broadcast services (fixed and mobile), and other services such as radionavigation, radiolocation, and sensing services used for scientific applications. The Commission is particularly interested in obtaining information on whether the RF environment and receiver interference immunity performance may have changed because of technological advancements, evolved spectrum management challenges, or changing spectrum use requirements in seeking to promote more efficient use of spectrum and greater access to spectrum for the introduction of new services. In asking about particular services, the Commission also invites comment on the extent to which considerations about receiver immunity performance parameters should be grouped based on these different service groupings, or whether instead some other analytical approach should be considered. Should there be different approaches to the Commission's consideration of receiver performance based on the particular services associated with the receiver, how the receiver might be integrated into other systems, and/or which services operate in adjacent or nearby bands?

In seeking comment below, the Commission notes that significant effort over the last few years has been devoted to providing more broadband services to the American public. In making allocation decisions and crafting service rules to accommodate this evolving landscape, spectrum use has intensified and the Commission has increasingly explored ways to provide for these valuable services by creating adjacencies that, in the past, would never have been contemplated. As an example, in the *3.7 GHz Report and Order* (85 FR 22804 (April 23, 2020)), the Commission repurposed fixed satellite downlink spectrum for terrestrial mobile broadband services resulting in separation of relatively high power terrestrial services from sensitive satellite earth stations by only a 20-megahertz guard band. This decision necessitated a thorough examination of the new RF environment and adoption of appropriate rules to ensure the satellite services could coexist with the new terrestrial operations.

In satellite services, receivers must be very sensitive to successfully receive the low level signals emanating from very distant satellites. As such, these receivers can be adversely affected by communications systems operating in adjacent or nearby bands. They may also experience interference from low level ambient noise sources that are below the minimum sensitivity level of typical receivers used in other radio services where the desired signal is significantly stronger. Whether satellite receivers could experience harmful interference effects from systems operating outside of the satellite bands depends on a variety of factors related to the types of operations in neighboring bands (*e.g.,* fixed versus mobile) and the technical operating parameters of those services (*e.g.,* power levels, out-of-band emissions (OOBE) limits, etc.), as well as the actual receiver interference immunity performance. The Commission invites comment on RF environment considerations with respect to satellite bands and adjacent or nearby band operations. What are the most important parameters to consider for services in adjacent bands to ensure compatibility with satellite services? The Commission seeks how best to characterize the adjacent band RF environment in reasonable performance metrics for satellite receivers. Is it anticipated that satellite receivers could improve their interference immunity? Over what time frame? How should the Commission characterize the RF environment for satellite services and the various trade-offs that are associated with providing full flexibility for services to operate in adjacent or nearby bands often with relatively higher power? What differences should be accounted for when considering fixed vs mobile and/or geosynchronous versus non-geosynchronous satellite operations? With today's demands for spectrum access to support new and innovative technologies, it is becoming increasingly necessary for the Commission to group unlike services adjacent to each other. To what extent, with today's technologies, is it necessary for the Commission to group like services adjacent to each other? As the Commission seeks to make more spectrum available for introduction of new services, including terrestrial services, what concerns and approaches should the Commission consider with respect to promoting improved receiver interference immunity to better accommodate the existing and anticipated future RF environment created by adjacent or nearby band operations?

Public safety operations often have stringent operational requirements to assure users such as police, fire and emergency medical service providers whose missions often involve safety of life, that their RF-based systems will function reliably in all circumstances. Given these requirements, what should the Commission take into account when making allocation or service rule decisions for bands adjacent to and nearby frequency bands used for public safety? How should these requirements be considered given the receiver immunity characteristics of today's public safety radios? How is such receiver immunity anticipated to change in the future and how would that affect the Commission's flexibility to make spectrum allocation and service rule decisions in adjacent and nearby bands as the RF environment changes? The Commission invites comment on how public safety services operate in today's RF environment, including how receivers operate effectively without experiencing harmful interference from adjacent or nearby band services. Are there special considerations regarding the RF environment in which public safety services operate that the Commission should take into account as it considers approaches to promote receiver performance for these services?

The Commission seeks similar information as it pertains to various mobile services, fixed services, broadcast services, and other services. Each service category presents different use cases with different dependencies on the RF environment. Mobile services include commercial mobile cellular networks that are characterized by a high degree of station and user density as well as movement of end-user devices in the vicinity of sectorized base stations with both fixed and steerable high gain antennas, public land mobile radio systems with comparatively lower density base stations and user devices but higher elevation base station antennas, and myriad other services

with distinct configurations and parameters. Fixed services are often characterized by highly directional (*e.g.,* point-to-point microwave) transmit and receive antennas, engineered to meet very high link reliability requirements. Broadcast services are often characterized by very tall antennas radiating high-powered signals to user terminals, either mobile or in fixed locations over large distances. Transmitters and receivers that serve location (position), navigation, timing, and space-based sensing services also may have particular RF performance characteristics. While receivers used in all of these services perform similar functions (*e.g.,* filtering, amplification, frequency conversion, etc.), the varied RF environment and applications for each service affect receiver design. How does the RF environment from adjacent and nearby bands affect the ability of users in each of these services to operate? What are the characteristics of current receivers that enable this coexistence and what is anticipated for future improvements? How does the current RF environment affect these services and how would more intensive spectrum use in the future change this RF environment? What steps can the Commission take to allocate services or assign users within and amongst these services with less spectral separation? What can users in these services do to adapt to the changing RF environment? Are there aspects of any of these services that may necessitate particular approaches to receiver performance, and if so what steps can be taken to ensure that receivers in any such service are sufficiently immune to interference from adjacent and nearby operations as the RF environment continues to change? Finally, the Commission asks if it should consider international implications for services that may have large international components, such as international flights or cargo shipping? Are there specific issues the Commission needs to consider regarding receivers that need to operate in a multitude of countries and territories? Commenters should address any international regulations (*e.g.,* for aviation safety) that should be taken into account.

Finally, the Commission invites comment on any other services that commenters believe have particular concerns not addressed above, and on which particular considerations should be given by the Commission with respect to RF environment.

Information on Transmitters and Receivers

The Commission inquires below about what information is currently available regarding existing incumbent wireless systems—with respect to transmitter characteristics, receiver characteristics, and an ''integrated systems analysis'' approach and receiver interference immunity performance concerns. In addition, the Commission requests comment below on the changing RF environment, including what kinds of changes are anticipated that the Commission might better prepare for, and how the Commission might establish its approaches that can effectively help ensure that receiver interference immunity performance concerns are addressed as the Commission takes future actions affecting the current RF environment to enable greater access to spectrum for new services and more efficient spectrum use.

Specific Information on Transmitter Characteristics

The Commission notes that, under the its long-standing approach to providing for the introduction of new services, the Commission and relevant stakeholders generally already have much significant information already available to them about transmitter characteristics based on the Commission's existing regulatory framework in which transmitters in particular services are required to meet various technical parameters (*e.g.,* power limits, antenna height, OOBE, etc.). This information is available for the transmitter operations whether authorized pursuant to rules associated with the licenses or authorized on an unlicensed basis (under part 15 rules). These rules often have been the primary means by which the Commission protects adjacent and nearby band operations, including incumbent receiver operations, from harmful interference.

As the Commission discusses in this document, efficient spectrum management seeks to optimize the ability of different types of services to operate in different allocations under specified rules in a manner that does not cause harmful interference to others' operations. As the Commission considers approaches to promoting receiver interference immunity performance, both transmitter and receiver characteristics are important for its consideration. This information is useful on a range of spectrum management issues, including adjacent band interference concerns, interference limits policies such as harm claim thresholds, quantitative risk-based assessment of interference, legacy devices, and cost-benefits, among others.

Discussion. The Commission invites comment on transmitter characteristics, as well whether more information would be useful as it pertains to the inquiry into receiver immunity performance.

The Commission seeks comment on the availability of information on transmitter characteristics in various frequency bands and the different services allocated to those bands. The Commission notes, of course, that its rules already provide limits for transmitters (*e.g.,* maximum power, OOBE limits, etc.), but the Commission seeks information on how typical operating values, both median and maximum levels, might differ from those regulatory limits. In cases where transmitters may typically operate below the regulatory limits, what factors influence those operating parameters? The Commission seeks this information for conducted and radiated power as well as for OOBE. How does the choice of antenna affect operational levels?

The Commission also inquires about additional transmitter characteristics that might be helpful to the Commission as it considers spectrum management options to improve receiver performance. How can the Commission implement an integrated systems approach that could promote spectrum policy that balances the burdens on transmitters and receivers and promotes improved receiver interference immunity performance where appropriate? In this context, the Commission notes that transmitters and receivers in different radio services (*e.g.,* fixed, mobile, satellite, broadcast, radio astronomy, etc.) have differing requirements. Should different metrics be used when evaluating systems in different services? What factors should the Commission take into account? In some instances, the Commission has used tools such as requiring PFD or field strength limits at various geographic boundaries or specific locations. Should the Commission use these techniques more often to provide additional protection to receivers? Likewise, are there requirements that can be placed on receivers if PFD, field strength limits, or other limits are placed on transmitters that would improve their immunity to harmful interference? What is the right balance for requiring either or both transmitters and receivers to comply with certain standards?

Specific Information on Receiver Characteristics

The Commission requests up-to-date information on what is currently known about receiver characteristics with respect to different services and operations across the radio spectrum bands. As noted in the TAC *White Paper on Interference Limits Policy* and TAC *White Paper on Risk-informed Interference Assessment,* relevant knowledge of both transmitter and receiver characteristics would be crucial for implementation of those approaches. Similarly, the *White Paper on Basic Principles for Assessing Compatibility of New Spectrum Allocations* recommended that services under Commission jurisdiction that seek protection from harmful interference should be expected to disclose the relevant standards, guidelines, and operating characteristics of their systems. While the Commission notes that several commenting parties supported gathering additional information on receiver characteristics, others opposed this based on proprietary and other concerns.

In addition, some reports have emphasized the importance of clarity about the RF environment and how the lack of information (often in the form of asymmetric information) available to relevant stakeholders, particularly with regard to receiving systems, can impede the ability of parties seeking to introduce new services to make appropriate choices to reduce potential interference, and have recommended improving transparency for operators by requiring the sharing of more information on technical characteristics that affect adjacent band operations. GAO also identified a lack of sharing among different industries when developing receiver specifications, and noted that one option for the Commission would be to gather additional information on the characteristics of the different systems, including receiver characteristics. CSMAC also believed that new entrants accessing spectrum should be made aware of the interference characteristics of receiving and transmitting equipment, and noted that filter performance of both receivers and transmitters were important considerations. Both GAO and CSMAC suggested consideration of establishing a repository or clearinghouse of information. Several reports, including GAO's, also have noted that, were the Commission to consider requiring that more information on receiver characteristics be made available, such a requirement raises concerns about confidential, proprietary, or classified information.

Discussion. The Commission invites comment on whether the Commission should consider requiring that more information about receiver characteristics be made available. Are there certain circumstances in which having additional information available to the Commission and relevant stakeholders would be helpful to introducing new services in adjacent or nearby bands? Could this information help serve the Commission's goal of providing for more efficient use of spectrum so that there is greater access to spectrum for new services? The Commission asks that commenters help the Commission as it considers whether to require additional information on receiver characteristics. If commenters support the availability of more information, the Commission invites commenters to indicate the types of information on receiver interference immunity performance would be most helpful in serving its goals of promoting more efficient use of spectrum and how best to manage the information.

The Commission requests that commenters discuss particular contexts in which having more information on receiver characteristics would be helpful, provided of course that any proprietary or classified concerns can be effectively addressed. As discussed elsewhere in this document, having sufficient relevant information regarding both transmitters and receivers is seen as a critical ingredient to promoting more efficient use of spectrum and providing a more effective pathway for addressing issues related to legacy receivers. With regard to voluntary approaches in which potential adjacent band use is under consideration, information on receiver characteristics could be helpful to all relevant stakeholders in order to address interference concerns.

The Commission seeks comment on whether there are services or bands in which commenters believe that additional information on receiver characteristics is not necessary, such as bands where necessary incentives are already in place for promoting receiver performance? On the other hand, what services or bands have insufficient available information on receiver characteristics, especially where the incentives are not sufficient with regard to promoting receiver performance? The Commission asks that commenter provide their thoughts about what factors the Commission might consider if it were to consider requiring the availability of more information on receiver characteristics.

Also, as noted, if the Commission were to consider requiring that more information be provided regarding receiver characteristics, how should the Commission address concerns around proprietary information, or other concerns? As for propriety concerns, would, for instance, the Commission's existing procedures for addressing parties' proprietary concerns in proceedings be an appropriate model? The Commission invites commenters to assist the Commission as it considers any potential requirements regarding information on receiver characteristics and the need to protect information that should not be publicly disclosed.

Integrated Systems Analysis

Understanding whole systems—both transmitters and receivers and their interaction under current rules and requirements can be an important consideration as the Commission seeks comment on the current RF environment. Two TAC White Papers proposed that the Commission focus more on an ''integrated systems'' approach as part of its spectrum management activities. An integrated systems approach takes into account every component of a radio based communication system involved with either the transmission and/or reception of a signal. The *White Paper on Spectrum Efficiency Metrics* discusses the potential role of an ''integrated systems'' approach in more effectively evaluating spectrum efficiency metrics. The *White Paper on Risk-informed Interference Assessment* recommends that the Commission should seek to include in its assessment of harmful interference a quantitative risk analysis, one which considers the various likelihood/consequence combinations for multiple different potential interference hazard scenarios among transmitters and receivers, which would complement the Commission's evaluation of other assessments as it determines how best to serve the public interest. Both of these approaches require that relevant information on potentially affected radio systems be available—including characteristics of both transmitters and receivers.

As the Commission has noted above, several reports have called for more transparency with respect to relevant information on both transmitters and receivers. Some also have called for developing a repository of information on transmitters and receivers.

Discussion. The Commission invites comment on whether the Commission should consider developing more of an integrated systems approach to spectrum management. What kinds of

information regarding transmitters and receivers would be relevant and helpful? Is there some way that more information on transmitters and receivers should be made more transparent and more readily available for the Commission or relevant stakeholders? To what extent would some form of repository be appropriate and helpful? If so, how would commenters suggest that any proprietary concerns be addressed.

Managing the Changing RF Environment

As the Commission has discussed, the RF environment continues to change in face of the need for greater access to spectrum for new uses. Given this, it is critical to address considerations affecting potential adjacent and nearby band interference concerns in an appropriate and timely fashion. It is important that as the Commission anticipates these changes the relevant stakeholders (*e.g.,* incumbents adjacent or nearby to bands that may be reallocated) are notified so that appropriate steps can be taken to address those stakeholders potentially affected. If improved receiver interference immunity performance would be appropriate, several also have recommended that the Commission provide for an appropriate transition or phase-in approach. GAO noted the lack of predictability about the changing future spectrum environment made it more difficult to accommodate repurposed uses of spectrum, and that it could take significant time and effort to upgrade and replace receivers where necessary.

Discussion. The Commission seeks comment on how the Commission can promote smoother and more effective transitions among potentially affected users as the RF environment continues to change to accommodate greater access to spectrum that serve the public interest. What steps should be taken to provide for greater predictability or transparency for potentially affected stakeholders, including those whose receivers may potentially be affected? How much advance notice from the Commission might be appropriate to provide to potentially affected stakeholders as the RF environment continues to change? In what ways should such advance notice be provided? What steps should the Commission consider to identify and inform potentially affected incumbent operators? To the extent that commenters believe that any particular past experiences regarding particular steps that either were taken, or could or should have been helpful if taken, the Commission asks that commenters offer their thoughts and recommendations for the Commission's consideration as it seeks to develop policies and take actions that promote better transitions in the future.

Also, considering that the RF environment can be anticipated to continue to change, the Commission seeks comment to whether and how the Commission could best clarify expectations for the performance of all radio equipment—both transmitters and receivers—in a changing RF environment. The Commission also invites comment on the importance of promoting more spectrally efficient devices that are designed to anticipate or assume that potential new uses of spectrum might occur in adjacent or nearby spectrum.

The Commission notes that it also raises some of these issues in a separate section below on potential Commission policy and guidance. In that section, the Commission requests comment on whether the Commission should consider providing additional policy or guidance specifically as to expectations that would apply to transmitters and receivers in adjacent band operations, including regarding expectations relating to receiver interference immunity performance.

Approaches for Promoting Improved Receiver Interference Immunity Performance

As the Commission seeks comment on various approaches to consider as it moves forward, it is important to provide an overall framework for considering how the Commission might incorporate receiver performance considerations into its spectrum management decision-making. The Commission inquires about whether and how to factor receiver interference immunity performance into spectrum policy in the form of incentives, guidelines, or regulatory requirements. These could include industry-led voluntary approaches, such as industry-developed guidelines and standards. They also could include additional Commission guidance, whether in terms of clarifying Commission policy, issuing a policy statement, or considering ways to advance approaches such as an interference limits policy, and/or a harm claim threshold approach where that might be helpful. The Commission also notes that in particular circumstances it might want to consider adopting specific rule requirements if other approaches would not be sufficient.

The Commission invites interested parties to provide their up-to-date views, observations, and recommendations on these different types of approaches that it discuss below. The Commission envisions that these approaches could include industry-led voluntary guidelines and efforts, additional Commission policy or guidelines, and specific mandatory requirements, and can be part of the solution in promoting improved receiver performance where that may be appropriate. The Commission seeks general comment here as to how these different approaches can work together to help optimize the promotion of receiver performance and other system design measures that would reduce susceptibility to interference and best serve the public interest. The Commission invites comments on how it might find an appropriate balance or mix of these different approaches.

Industry-Led Voluntary Approaches

In this section, the Commission requests that commenters provide up-to-date information on various industry-led voluntary approaches, including standards and guidelines, that currently promote receiver performance. The Commission requests comment on where voluntary approaches are effective, where they could be more effective, and what the Commission could consider in order to enhance the effectiveness of voluntary approaches.

The Commission notes that in the 2003 *NOI on Receiver Performance Specifications* the Commission expressed a general preference for relying primarily on voluntary approaches and guidelines that are supported and managed by industry, in conjunction with user groups as appropriate, believing this approach is most flexible and responsive to changes in technology, consumer desires, and economic conditions. The Commission believes that spectrum users such as commercial spectrum licensees often have the requisite incentives to reach voluntary agreements that provide for additional spectrum use. At the same time, however, it recognized that a purely voluntary approach may produce an incumbency problem if owners of non-conforming receivers limit efficient use of spectrum. The Commission inquired specifically about various voluntary approaches at that time, and many commenters in that proceeding generally supported a voluntary approach to improving receivers (such as through development of industry standards and guidelines). Since that time, many have continued to assert that voluntary approaches are the most efficient and effective means of promoting receiver performance and promote more efficient use of spectrum.

The Commission continues to believe that the development and implementation of various voluntary approaches, taken together throughout the wireless sector, in many situations can provide the best and most effective means of promoting interference immunity in the most efficient and effective way. The Commission seeks detailed comment on the various ways in which voluntary standards and guidelines have, and will continue to, serve its goal of promoting improvements in receiver performance that will enable greater access to spectrum. To what extent are voluntary approaches sufficient to ensure that minimum receiver interference immunity performance can be achieved in some or all bands?

As the Commission considers voluntary standards and guidelines, the Commission also notes that several studies and commenters have pointed out challenges that may be associated with the development of voluntary approaches in certain situations, either because the necessary incentives may not be present or the necessary information may not be available. While describing several voluntary efforts have helped improve receiver interference immunity performance, GAO also noted that in many situations there were challenges that affect the development of voluntary standards, including the lack of coordination across industries when developing voluntary standards (*e.g.,* while standards may be developed by a single industry, these standards may not be coordinated with representatives of others that could be affected, such as adjacent band users). GAO also noted that there could be a lack of incentives for manufacturers and spectrum users to incur costs associated with using more robust receivers (noting that there may be few incentives for users in one band to incur costs to improving receivers for operations if the adjacent band users gain the benefits); it concluded that, even though there can be sufficient incentives for addressing receiver performance within the same service, such incentives often do not exist for different services or adjacent band services.

Several reports and commenters have suggested that voluntary approaches could benefit from the use of multi-stakeholder groups in helping develop appropriate voluntary standards. Several also noted, however, that oftentimes not all of the relevant stakeholders (*e.g.,* those potentially affected by the development of voluntary standards, including those with interests associated with adjacent band use), participated in the development of voluntary standards.

GAO also noted that a compendium of current industry standards or guidance may not always be available, and could help facilitate knowledge on any standards or guidelines. Finally, GAO pointed out that, while voluntary standards and guidelines could help promote receiver performance, the extent to which they are in fact used is generally unknown.

Discussion. In this document, the Commission invites comment from interested parties to provide up-to-date information on the various voluntary approaches, including industry-led approaches, that currently serve to promote better receiver performance and generally more interference-resistant system designs. The Commission inquires about their views on the role of voluntary standards and guidelines to promote improved receiver performance by providing greater resilience to harmful interference, promote more efficient use of spectrum, and enable innovative new services to be introduced. The Commission also inquires about the steps it might take to promote development and use of voluntary standards and guidelines.

The Commission invites comment on whether voluntary standards and guidelines that have previously existed or currently exist serve as an effective means of promoting receiver performance. What are these standards and guidelines, and how effective have they been in promoting receiver performance? Which industries helped to establish them, and which stakeholders were involved in their development? Are these standards or guidelines publicly available? The Commission invites broad comment on where these approaches work well and help promote receiver performance in today's RF environment and could help promote improvements in a changing RF environment. The Commission asks commenters to comment on the extent to which the necessary incentives are in place to develop effective voluntary approaches.

The Commission requests comment on whether there could be improvements in the ways that voluntary approaches can be developed and used. To what extent have such efforts included relevant stakeholders? If additional stakeholders could help improve such voluntary efforts, how might they be involved in future efforts.

The Commission also requests comment on situations or cases in which current voluntary approaches may not be sufficient with respect to promote improved receivers in certain situations and contexts (*e.g.,* addressing adjacent band compatibility issues). The Commission asks that commenters identify and discuss situations in which voluntary approaches may not promote improvements in receiver performance where that would help promote more efficient use of spectrum. Are there ways to ensure that there are appropriate incentives for promoting effective voluntary approaches?

The Commission invites comment as to the appropriate role for multi-stakeholder groups in this process. Are there particular situations in which commenters believe a multi-stakeholder group involvement would be appropriate? If so, which stakeholders should be involved, and how?

As discussed elsewhere in this document, the Commission is seeking comment about both transmitter and receiver characteristics as it considers approaches to improving receiver performance. The Commission seeks comment on whether more transparent or available information on transmitters and receivers could help promote more effective voluntary approaches.

Finally, the Commission requests comment on whether and how it could help promote effective voluntary approaches.

Commission Policy and Guidance

In this section, the Commission inquire about the kinds of policy and guidance that could be helpful as the it considers whether and how to incorporate receiver performance more directly into spectrum management decisions. The Commission recognizes that such policy and guidance could take many forms, and some mix of approaches may be appropriate; the Commission invites commenters to help as it considers these various approaches.

Many contend that the Commission's general spectrum management policy on the role of receiver interference immunity performance should be clarified. Some have suggested that the Commission's approach to date on receiver performance is not been sufficiently conducive to promoting more efficient spectrum use or promoting greater access to the spectrum resources for new services and uses. For instance, in the *White Paper on Interference Limits Policy* the TAC Working Group suggested that expectations of receiver performance have almost always been implicit and often based solely on the ability of the receiver to perform its desired function in the existing spectral environment, which has led to conflicts due to a change in the RF environment and/or a

differing understanding of requisite receiver performance. Authors in one paper recommended that, in order to provide better incentives to build more interference-robust systems in future allocations and put more spectrum to its highest and best use, the Commission should move away from any general interference protection model in spectrum management that, when considering permitting new services in adjacent bands, often provides incumbent users (those licensed first) protection against any interference resulting from subsequent rule changes. They stated that adjacent band interference protection for incumbents should not be static, and that incumbents should be incentivized to improve their systems' interference resilience in the most cost-effective way, including the use of receivers that are more interference-immune to interference exposure from adjacent bands.

One report observed that certain assumptions that many spectrum users make are not conducive to promoting more efficient use of spectrum—including that operators of wireless systems tend to rely on their neighbors being quiet, often do not account for changes in the RF environment, and often do not realize that receivers are a part of the problem (and instead assume that the neighboring transmitters are the problem). That report also concluded that there is ''poor knowledge transfer'' among all affected parties regarding the interference problems related to receiver performance and potential resolution, and suggested that regulators could provide more helpful notice to operators regarding the need for better receivers. Another report recommended improved transparency for operators (*e.g.,* sharing more information on the characteristics of their neighbors' adjacent operations, establishing a device performance registry, incentivizing operators to divulge the required information); they also stated that more incentives should be provided for promoting more robust receivers, possibly including issuance of a Commission Policy Statement (*e.g.,* to the effect that receivers would no longer be protected if they do not include appropriate receiver selectivity).

GAO also noted in its report that current practices and policies related to receiver performance may in effect constrain repurposing of spectrum, and that the lack of predictability about future spectrum management also could be a hindrance to a more effective spectrum policy. CSMAC stated that spectrum managers should consider incentives, rules, and policies to improve the capability of receiving devices to reject adjacent channel interference. The Commission also notes that the *Presidential Memorandum on Wireless Innovation* encouraged the development of measures concerning receivers that would promote design and deployment of receivers that are protected from harmful interference from adjacent band operations in cases where there is ''reasonable use'' of adjacent band spectrum. Several have emphasized that as the Commission considers developing new policies or guidance, it also considers whether some transition or phase-in period would be appropriate.

Below the Commission considers several possible approaches and invite comment. These include (1) providing clearer Commission policy guidance on the role of receivers and expectations about their performance; (2) gathering relevant information on receiver characteristics; (3) issuing a policy statement; and (4) promoting an interference limit policy such as harm claim threshold approaches where that might be appropriate. The Commission also inquires about whether it should consider any of these approaches, a transition or phase-in of some kind might be appropriate.

General Policy Guidance

The Commission first seeks comment on whether it should consider establishing clearer guidance on Commission policies relating to receivers and receiver performance in spectrum management going forward. The Commission inquires whether such policy guidance could serve to establish clearer expectations for all spectrum users as to receiver performance, including in the future as the Commission seeks to enable greater access to spectrum for new users and promote more efficient use of spectrum by receivers. The Commission also inquires whether and how a clearer policy could help incentivize a more forward-looking approach to the role of improved receiver performance in a changing RF environment.

The Commission offers possible approaches below and seeks comment. The Commission also invites commenters to identify other approaches regarding Commission policy that it should consider.

Establishing clearer expectations about the extent to which incumbent receivers will receive interference protection as new services are introduced. As noted above, some have suggested that in order to promote greater access to spectrum and promote more efficient use of spectrum, the Commission should establish clearer policies on the extent to which incumbent receivers will be protected in the future regardless of spectrum efficiency concerns. In particular, some state that the Commission should be more transparent that incumbent receiver operators should not simply assume that the introduction of transmitters in adjacent or nearby bands is the entire focus for addressing interference compatibility issues or that receiver performance will not be considered in the Commission's spectrum management decisions. The Commission invites comment on whether it should establish a clearer or explicit policy regarding the extent to which incumbent receivers will receive interference protection as the RF environment continues to change and new services are introduced into adjacent or nearby bands. The Commission also requests that, to the extent commenters believe such policy clarification would be beneficial, they suggest the types of clarifications that the Commission should consider. To what extent would such a policy-based expectation require clarification of incumbent users' spectrum rights and responsibilities?

The Commission also invites comment on how such a policy clarification might be implemented with regard to incumbent users. When might such a policy make sense? How might such a policy be implemented with respect to adjacent band operations, including when both services have primary allocations? As to implementation of such an approach, what kinds of factors and timeframes should be considered? For instance, should the amount of time an adjacent band incumbent has been operating be a factor in considering what action the Commission should take? Should the expected life (*e.g.,* average useful life) of receivers in the affected band be considered to reduce the potential for stranded investments?

Clarifying the importance of assigned frequency bands and allocations with respect to receiver performance. Several have suggested or recommended that one component of better spectrum management would include Commission clarification of the respective responsibilities associated with both transmitters *and* receivers in spectrum allocations and assignments, and that this could include being more explicit regarding whether receiver interference immunity performance should be tied to the allocation or assignment under which the receivers are authorized. In the 2003 *NOI on Receiver Performance Specifications,* for instance, the Commission specifically

inquired about how receiver performance should be related to the management of spectrum and uses in adjacent bands, including whether the definition of assigned frequency bands and areas already provided ''substantial definition to the interference environment in which licensees must design their systems.''

The Commission also notes that the TAC's *White Paper on Basic Principles for Assessing Compatibility of New Spectrum Allocations* proposed that the Commission consider establishing ''Basic Principles'' regarding both transmitters and receivers with respect to spectrum allocations, and specifically proposed as one principle that ''[r]eceivers are responsible for mitigating interference outside their assigned channels'' (while it also proposed that ''[t]ransmitters are responsible for minimizing the amount of their transmitted energy that appears outside their assigned frequencies and licensed areas''). Further, the Commission notes that ITU Radio Regulations, for instance, recognize the importance of expectations regarding receiver performance, and provide that receivers should provide adequate performance such that they do not suffer from interference from transmitters operating at a reasonable distance. Also, as the Commission has discussed above, recent proceedings have highlighted the relationship of receiver performance vis-à-vis assigned frequency bands and allocations, as well as expectations on receiver performance regarding interference from adjacent or nearby operators.

Accordingly, the Commission inquires whether the Commission's spectrum management policy should clarify that, as a general matter of the spectrum regulatory policy, receiver manufacturers and operators are expected to take into account their allocation and assignment, or take into consideration designing and using receivers that include interference immunity parameters that would ensure coexistence with transmitters operating with reasonable spectral separation from the band in which the receivers are authorized to operate. To the extent that commenters believe that policy guidance is appropriate, the Commission asks that they propose specifics about the guidance they think appropriate, explain why, and, depending upon the guidance they suggest, indicate the extent to which a transition period may be appropriate.

Development of performance criteria or ratings. The Commission also invites comment on whether it should consider developing particular receiver performance criteria, or some form of ratings, that would serve to encourage the design, manufacturer, and deployment of receivers that promote receiver interference immunity and adequately protect the receivers from interference from current and future uses of adjacent band spectrum. If the Commission were to consider developing performance criteria or ratings, how would these be developed? With regard to performance criteria, what specific metric(s) should the Commission consider? For instance, should the criteria be tied to a certain level of performance at the edge of the allocation? The Commission asks that commenters suggest specific criteria and explain their rationale for such criteria. Similarly, the Commission invites comment on whether some form of ratings should be considered. If so, what would comprise the ratings, how many levels of ratings would be appropriate, and how would the ratings be determined? Can ratings effectively be designed that would aide operators and consumers in using more interference immune receivers? Could particular receiver performance criteria or ratings be developed that could be incorporated into voluntary standards or Commission requirements? How might performance criteria or ratings best be implemented?

Informing relevant stakeholders of any Commission forthcoming policy guidance. If the Commission were to provide additional policy guidance, the Commission recognizes that it would be important that potentially affected stakeholders are apprised of the guidance. The Commission asks for comment on how the means by which it and others could most effectively identify and communicate such policy guidance.

Transitions. If the Commission were to consider providing additional policy guidance, the Commission invites comment on the considerations that would be associated with policy implementation. Depending on the policy guidance, are there particular transition concerns that the Commission should take as to receivers that may need to be repaired, modified, or replaced? Would such considerations depend on the particulars involved as to specific situations and bands? The Commission asks that commenters help it take into account the various factors that should be considered.

Other policy guidance. The Commission invites commenters to offer other ideas or measures for Commission consideration regarding further guidance. Commenters should explain their suggestions and provide detailed discussion of why such policy guidance would be appropriate and how the Commission might consider implementing such guidance.

Policy Statement

In this section the Commission invites comment on whether the Commission should consider issuing a policy statement to establish a clear and transparent Commission policy that can help bring receiver interference immunity performance into fuller consideration in spectrum management decisions, as some have suggested. The Commission first inquires generally whether a policy statement would be constructive. The Commission then inquires about possible models for a policy statement.

Issuing a policy statement. Through the years, the Commission has issued various policy statements to guide public considerations and to advance spectrum management pursuits. For instance, in 1999 the Commission issued a Policy Statement on ''Principles for Reallocation of Spectrum to Encourage Development of Telecommunications Technologies for the New Millennium,'' in which the Commission noted the unparalleled growth of wireless services in the 1990s and ''set forth guiding principles for the Commission's spectrum management activities''—including ways to promote greater efficiency in spectrum markets, make more spectrum available, and identify new bands for spectrum reallocation—as the Commission engaged in spectrum management in 2000 and beyond. In 2000, the Commission issued its Policy Statement on ''Principles for Promoting the Efficient Use of Spectrum by Encouraging the Development of Secondary Markets,'' in which it set forth the Commission's vision and plans for facilitating secondary markets for radio spectrum that will allow and encourage licensees to make all or portions of their assigned frequencies or service areas available to other entities and uses. Both Policy Statements helped lay the foundation for the Commission's forthcoming rulemakings implementing some of the enunciated policies in the early 2000s.

In recommending that the Commission create more incentives for building more robust receivers, Silicon Flatirons suggested that issuance of a policy statement could be useful. Also, as discussed above, many commenters and reports have called for greater Commission clarity on how receiver performance considerations should be factored into the Commission's spectrum management in ways that would provide clearer expectations and

greater predictability for all spectrum users in the future.

The Commission seeks comment on whether it should consider issuing a policy statement to more directly and transparently incorporate relevant and appropriate focus on receivers as part of a balanced approach—*i.e.,* considering the important role of both transmitters and receivers—to promoting more efficient spectrum use in the Commission's spectrum management decision-making. Would adoption of a policy statement be helpful in promoting the Commission's efforts to incorporate receiver interference immunity performance considerations and promote more efficient spectrum use in the current and evolving RF environment? What purposes could be served by issuance of a policy statement? Would a policy statement, for instance, help establish clearer expectations and greater predictability for spectrum users going forward?

If the Commission were to consider issuing a policy statement, what specific framework, features, factors, or statements should be included? The Commission asks that commenters in favor of the issuance of a policy statement set forth their recommendations, including discussion of the various goals of the policy statement, any suggested language, and the reasons for such language.

Possible models for a policy statement. The Commission invites comment on possible models for crafting a policy statement. Commenters should identify any such models, and any specific framework or language in those models that they believe should be considered.

In particular, the Commission inquires whether the TAC's *White Paper on Basic Principles for Assessing Compatibility of New Spectrum Allocations* or some modification or variant of that framework, could supply a possible and constructive framework for consideration in developing a future Commission policy statement. As the TAC explained:

> Basic principles of spectrum utilization are important for all involved parties to consider, not just the regulatory authorities. Realization of certain facts of communications technology will temper the expectations of the incumbent services using spectrum resources as well as the new services that are trying to gain entry into the spectrum.

As contemplated, with the nine ''basic principles'' the TAC sought to promote ''good neighbor policies'' among spectrum users (generally found at spectral boundaries) that better enable adjacent and nearby spectrum users to ''get along'' with each other. Several of these principles directly related to expectations about both transmitters and receivers. Given the many differences between the requirements of various types of systems, the TAC did not expect the application of these principles to result in a concrete set of regulations that fit all radio services in the same way, but nonetheless believed that the principles can be applied to all systems and result in an optimal solution for each service. As discussed in the basic principles below, several of the principles focused on establishing expectations and responsibilities concerning receiver performance within the larger context of spectrum management, including establishing that harmful interference is affected by the characteristics of both a transmitting service and a nearby receiving service, that receivers are responsible for mitigating interference outside their assigned channels, and that services under the FCC's jurisdiction are expected to disclose the relevant standards, guidelines and characteristics of their systems if they expect protection from harmful interference.

The basic principles identified by the TAC Working Group included three functional groups—''Interference Realities'' (realities of interference everyone must accept), ''Responsibilities of Services'' (responsibilities that services have to mitigate their interaction with other services), and ''Regulatory Requirements and Actions'' (requirements for, and actions that should be taken by, regulatory authorities with respect to spectrum allocations):

Interference Realities—

- *Principle 1:* Harmful interference is affected by the characteristics of both a transmitting service and a nearby receiving service in frequency, space or time.
- *Principle 2:* All services should plan for non-harmful interference from signals that are nearby in frequency, space or time, both now and for any changes that occur in the future.
- *Principle 3:* Even under ideal conditions, the electromagnetic environment is unpredictable. Operators should expect and plan for occasional service degradation or interruption. The Commission should not base its rules on exceptional events.

Responsibilities of Services.

- *Principle 4:* Receivers are responsible for mitigating interference outside their assigned channels;
- *Principle 5:* Systems are expected to use techniques at all layers of the stack to mitigate degradation from interference; and
- *Principle 6:* Transmitters are responsible for minimizing the amount of their transmitted energy that appears outside their assigned frequencies and licensed areas.

Regulatory Requirements and Actions.

- *Principle 7:* Services under FCC jurisdiction are expected to disclose the relevant standards, guidelines and operating characteristics of their systems to the Commission if they expect protection from harmful interference;
- *Principle 8:* The Commission may apply Interference Limits to quantify rights of protection from harmful interference.
- *Principle 9:* A quantitative analysis of interactions between services shall be required before the Commission can make decisions regarding levels of protection.

The Commission notes that several commenters expressed interest in having it explore these principles insofar as they pertained to expectations and responsibilities associated with receivers and receiver interference immunity performance, while others expressed particular concern about particular principles and their application to certain types of receivers. The Commission invites comment on the principles in the White Paper as they concern a Commission policy statement. Commenters should discuss their views and concerns on particular principles, and whether revisions or clarifications on any of the principles or on their applicability should be considered.

The Commission also asks whether there are other models that the Commission could draw from as it considers a policy statement. For instance, would ITU Radio Regulations (RR) or relevant ITU–R publications (*e.g.,* ITU–R recommendations) that pertain to receiver performance (along with transmitter performance) provide a useful framework or particular language for consideration? As discussed above, several provisions in the Radio Regulations concern ''technical characteristics of stations'' associated with both the transmitter and receiver equipment and performance with respect to each other and in promoting more efficient and effective use of spectrum. As regards receivers in particular, the ITU provided regulations on several aspects on the role of receiver design and performance that would that serve to promote more efficient use of spectrum—including receiver design (RR No. 3.3—taking into account technical measures to reduce susceptibility to interference), bandwidth considerations (RR No. 3.9—

keeping bandwidths at lowest values that the service permits), spectrum efficiency (RR No. 3.11—receivers should promote efficient use of spectrum), technical characteristics (RR No. 3.12—receiver selectivity that ensures efficient utilization of spectrum), and performance characteristics (RR No. 3.13—sufficient levels of receiver interference immunity performance so that receivers do not suffer from interference from transmitters operating at ''a reasonable distance''). Would any of these ITU references provide helpful guidance for consideration to be included in a Commission policy statement? Similarly, would the European Union Radio Equipment Directive provide useful guidance? That Directive also recognized the important role of both transmitter and receiver equipment in spectrum management. The Directive further indicated that ''Essential Requirements'' includes a requirement that radio equipment (both transmitters and receivers) should be constructed so as to ensure ''an adequate level of electromagnetic compatibility'' and in a manner that ''both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference.

Finally, the Commission invites comment on any other models or other sources (*e.g.,* proposals, reports, studies, etc.) that could provide useful discussion for Commission consideration about a policy statement and specific features or language that should be included.

Interference Limits Policy, Including Harm Claim Thresholds

In the *White Paper on Interference Limits Policy* issued in 2013, the TAC discussed an interference limits policy as well as one particular form of such a policy, harm claim thresholds. In 2014, the TAC followed up this discussion with its *White Paper on Harm Claim Thresholds.* The TAC Working Groups authoring these two White Papers believed that an interference limits policy would promote more transparent consideration of receivers in spectrum management and promote better receiver performance policy in a more flexible manner if the Commission adopted receiver performance mandates. As discussed below, many commenters were in favor of the Commission further exploring interference limits policy, and harm claim thresholds in particular.

The Commission summarizes at a high level these approaches below—but it direct commenters to review and address the details set forth in the two White Papers themselves. The Commission invites comment on whether and how an interference limits policy, and a harm claim thresholds approach in particular, should be considered by the Commission.

In these papers, the TAC working groups noted that, in order to meet the growing demand for wireless service, the number of wireless systems that operate in close proximity in frequency, space, and time need to increase, and that while there are many benefits derived from packing wireless systems among these dimensions (*i.e.,* higher system density), there is also an increased risk of service disruption due to inter-service interference. The TAC stated that implementing an interference limit policy would bring receivers into the spectrum management picture, and do so with minimal regulatory intervention. As explained in the *White Paper on Interference Limits Policy:*

> Increased density requires more care in optimizing the whole wireless system structure, particularly regarding the interactions between transmitters and receivers on either side of band boundaries. . . . [R]eceivers that cannot reject interfering signals transmitted outside their assigned frequencies can preclude or constrain new allocations in adjacent bands. A holistic system view that facilitates trade-offs between receiver and transmitter performance requirements is needed.
>
> Receivers can be brought into the policy picture with minimal regulatory intervention by introducing an ''interference limits'' policy; that is, the establishment of ceilings, called *harm claim thresholds,* on in-band and out-of-band interfering signals that must be exceeded before a radio system can claim that it is experiencing harmful interference. Manufacturers and operators are left to determine whether and how to build receivers that can tolerate such interference, or even determine that they will choose to ignore these limits. Harm claim thresholds thus allow the FCC to provide guidance on the optimization of receiver performance without unduly restricting technical and commercial choice.

The TAC contemplated rules that explicitly state when receivers may and may not claim harmful interference. Such rules would be a necessary complement to existing transmitter regulation that could facilitate the transition to more intensive frequency use by providing more clarity to service providers about the baseline regulatory and radio interference context going forward. The TAC stated that harm claim thresholds could be particularly useful in bands with many diverse and frequently emerging new technologies. As envisioned, the approach would delegate decisions about system design, including receiver performance, to manufacturers and operators, giving operators the flexibility to decide best how to deal with the RF environment (*i.e.,* signal levels in adjacent or nearby bands which may be viewed as interference) they need to tolerate, whether by improving receiver selectivity, deploying more base stations, using internal guard bands, or accepting occasional service degradation given their choice of receiver design. Further, under such an approach, the private sector would play a key role in developing receiver specifications and standards that ensure adequate performance given the harm claim thresholds of a particular allocation. The TAC also recognized, however, that a harm claim threshold approach may require special consideration in cases where receivers are not controlled by a license holder or for life-safety systems like aviation and public safety.

As the *White Paper on Harm Claim Thresholds* explained, the goal of a harm claim threshold is to reduce the uncertainty among radio system operators regarding the level of interference that one operator is entitled to impose on another operator, and that a related goal has been to find ways the Commission could encourage more efficient radio service coexistence, including ways to encourage receiver performance improvement without mandating receiver performance specifications. As articulated in the *White Paper on Interference Limits,* a guiding principle of this approach is that the number of interference disputes that require Commission resolution could be reduced if the responsibility to mitigate interference is more clearly assigned (*i.e.,* if lines are more clearly drawn between the rights of transmitters and receivers).

The TAC recommended that the Commission develop, where necessary, the expertise and that multi-stakeholder groups form to investigate interference limits policy at suitable high-value inter-service boundaries and suggested potential ways about implementing an interference limits policy. The TAC suggested introducing a harm claim thresholds approach on a gradual basis and suggested a three-step process for how the Commission might roll out rules and regulations on an interference limits policy, including harm claim thresholds. First, the Commission could identify frequency allocation boundaries where harm claim thresholds would bring immediate value, such as adjacent allocations where intensified use is anticipated. Second, the Commission would initiate a consultation process involving stakeholders in multiple services that span band boundaries.

Such multi-stakeholder groups could work collectively to develop options at these spectrum boundaries (*e.g.,* methods for determining harm claim thresholds, enforcement and conflict adjudication mechanisms) as well as develop guidelines (and perhaps standards) for receiver performance parameters such as receiver sensitivity, selectivity, intermodulation rejection, and dynamic range, that, together with the transmitter power, signal modulation and deployment assumptions applicable to a particular service, would ensure that conformant receivers would operate satisfactorily within an RF environment where signal levels are no greater than the harm claim threshold. Third, the Commission would monitor the progress of the multi-stakeholder process, representing the interests of future licensees and other absent stakeholders while also ensuring that the record developed provides a thorough basis for a rulemaking should that be appropriate.

Many commenters on the *White Paper on Interference Limits Policy* believed that the concepts deserved further consideration. Others, while acknowledging the need to consider an interference limits approach, opposed applying such an approach to particular services (*e.g.,* aviation safety, safety-of-life services, amateur radio, or commercial mobile services) stating that a one-size-fits-all approach would not be appropriate. Some commenters, noting the difficult methodological and administrative implementation issues associated with this approach, stated that the Commission should explore and promote industry receiver performance measurements and some thought it important to develop appropriate enforcement mechanisms for any limits adopted. Many supported use of multi-stakeholder groups for formulating possible interference limits provided that appropriate representatives would participate. Some commenters supported the Commission using a pilot project to explore the approach in an appropriate band.

In addition to the TAC, other entities recommended that the Commission further explore an interference limits policy, including harm claim threshold approaches. These included reports noting panelists' consensus that a protection limits approach generally was preferable to adoption of receiver standards, and a later report largely supportive of developing an interference limits policy approach, including harm claim thresholds approach along with using multi-stakeholder groups to help develop appropriate technical solutions. One paper has proposed a specific harm claims threshold approach in which the threshold would be based on the interference environment associated with flexible use in the adjacent bands. PCAST also supported the harm claims threshold approach for receiver interference limits, which it contrasted with use of ''heavy regulation of spectrum and devices'' to solve receiver-driven interference issues. It believed that such an approach would provide a framework for defining harmful interference, could provide clarity on the requirements that a new entrant must meet to co-exist with legacy systems in adjacent bands, and would give device manufacturers freedom to address those requirements as they see fit. GAO also noted one of the Commission's clear options for promoting receiver performance was further consideration of an interference limits approach.

Discussion. In this document, the Commission seeks to develop an up-to-date record on whether the Commission should further explore implementing an interference limits policy, and in particular, a harm claim thresholds approach. The Commission ask that commenters review the two TAC whitepapers, and offer their thoughts on the details discussed there, the issues and concerns raised, and how the Commission might proceed in consideration of interference limits policy and harm claim thresholds. In particular, the Commission seeks comment on how such an approach would fit into today's spectrum environment characterized by much more intensive use compared to when these recommendations were developed. How could this approach alleviate spectrum issues the Commission is currently addressing as well as anticipated trouble spots as the Commission continues to examine opportunities for reallocating spectrum for higher valued uses? Should the Commission consider adopting any rules to implement such a policy?

The Commission notes that the TAC recommended in the *White Paper on Interference Limits Policy* that the Commission issue a Notice of Inquiry seeking public comment on interference limits policy. First, the Commission seeks comment on the use of an interference limits policy at service boundaries in general, including the tradeoffs between interference limits policy and three alternatives to an interference limits policy that were noted in the *White Paper on Interference Limits Policy.* To focus this inquiry quantitatively, the Commission seeks comment on the use of an interference limits policy at service boundaries where there are legacy receivers for one of the radio services for which there are no published or industry-standard minimum out-of-band blocking threshold(s). Commenters should identify inter-service boundaries where there are some legacy receivers that are unable, for example, to tolerate fundamental signal levels outside their receive band that are more than 2%–10% displaced from the legacy receiver band edge and less than −15 dBm at the receiver input port (after antenna losses, prior to RF filter attenuation). Commenters that support different metrics for examining inter-service boundaries are encouraged to provide such metrics along with detailed explanations to support their choices as well as the boundaries where they should apply. The Commission is interested in knowing where legacy receivers are deployed that are designed and compliant with widely accepted industry receiver standards that include minimum out-of-band blocking (*i.e.,* overload) tolerance specifications (*e.g.,* radio receivers such as 3GPP base stations, user devices, aviation certified GPS receivers, etc.). Similarly, the Commission seeks information on where receivers are deployed that are not built to such standards, yet seek protection from signals outside their band. And the Commission requests that commenters identify the types of legacy receivers that are in the category identified by the TAC where interference limit policies may not be necessary at all. The Commission's goal is to build a quantitative record based on commenters' experience and spectrum viewpoints to inform the Commission where they believe high-value interservice boundaries exist and where interference problems can be foreseen that could benefit from proactively implementing a harm claim threshold approach to specify licensees' responsibilities for interference risk mitigation.

Second, the Commission seeks comment on institutional approaches for implementing harm claim thresholds, including the use of multi-stakeholder processes, rulemaking, and in particular, inter-industry standards setting processes. The Commission seeks comment on specific tasks or reports that a multi-stakeholder group should address that would aid it if it were to further examine implementing a harm claim threshold approach. For example, would a multi-stakeholder group be able to evaluate any high value interservice boundaries identified by commenters and provide consensus insight into which spectrum allocations

should be addressed first or which would provide the largest benefits? Additionally, could a multi-stakeholder group compile data and produce a report or database regarding relevant technical specifications of deployed receivers including, but not limited to relative and absolute dynamic range, out-of-band blocking tolerance, and selectivity, where public owners of such receivers, other potentially affected spectrum users, and the Commission, do not have transparent insight? Such information could inform policy decisions and actions to balance transmitter emission power with receiver reception limits. What other tasks could a multi-stakeholder group tackle to help this process?

Similarly, how can industry standards processes be leveraged to provide for improved receiver performance to support a harm claim threshold approach? In this regard, the Commission is not seeking to build a record to mandate the ''design'' of receivers that could chill technology evolution, but instead, the Commission is seeking ideas on how the importance of good receiver design can more effectively be represented in the lifecycle of receiver development and product evolution processes. For example, for receivers that require protection from fundamental signals in adjacent or nearby spectrum bands, the minimum undesired out-of-band power at which those receivers can operate without a degradation metric exceeding a low minimum, could be specified in an industry standard. The Commission notes that this is already done in some standards groups. Alternatively, specific receiver requirements can be specified as a receiver mandate in the Commission's rules or absent such specificity, left to industry to meet a harm claim threshold signal strength or power flux over-the-air specification (*i.e.,* signal-in-space) which could be codified in its rules. The Commission seeks comment on these alternatives and their tradeoffs.

Third, the Commission seeks comment on suitable parameters for harm claim thresholds, engineering methods to determine their values, and ongoing reporting, analysis, and enforcement challenges. For example, should the Commission consider whether to adopt a standard ''reference value of far out-of-band blocking power'' to evaluate inter-radio-service interference scenarios. If so, what value would be appropriate? Would a standard reference value such as −15 dBm at the input to a receiver's front-end filter, be useful in the early identification of suitable harm claim thresholds; *i.e.,* identifying harm claim thresholds that may be ''at,'' ''above,'' or ''below'' a standard reference value? If this value is inappropriate, what value would be appropriate? Should different values be specified for different radio services? If so, the Commission requests that commenters justify their position and provide detailed comment regarding recommended values and which radio services are applicable. Are there instances in which the harm claim threshold should be set based on assuming that the allocation in the adjacent band would be flexible use? How can the Commission incentivize industry segments where there are no consensus receiver standards, yet there is a desire for ''protection'' from inter-band interference? Since the responsibility for spectrum coexistence lies with both transmitters and receivers, can these (or other) harm claim threshold parameters be used to achieve the Commission's policy goals?

The Commission also seeks comment on whether a harm claim threshold approach should incorporate two parameters that 3GPP has used to study the balance of transmitter impairments with receiver impairments: Adjacent Channel Leakage Ratio (ACLR) and Adjacent Channel Selectivity (ACS). These parameters are used to analyze and determine the balance between transmitter and receiver impairments within spectrum bands shared between multiple mobile broadband service providers using a basic formulation called Adjacent Channel Interference Ratio (ACIR). While the Commission is unaware of anyone applying this concept ''between inter-service spectrum bands'' (*i.e.,* between different radio services) to assess whether out-of-band transmitter impairments or out-of-band blocking receiver filter impairments dominate the interference equation between spectrum bands, it seeks comment on whether these concepts can be used in this context. For commenters that support such an approach, the Commission requests specific information regarding how these concepts could be applied and what values should be considered for evaluation purposes for various radio services.

Are there specific engineering methods or analysis tools that lend themselves to analyses necessary to support a harm claim threshold approach? In particular, a harm claim threshold approach may require specifying an ''over the air'' power flux or field strength threshold, over which ''claims of harm'' could be made, and under which claims of harm could not be made. Spatial and temporal variables associated with transmitters and receivers, especially mobile radio, present a statistical challenge to assess probabilistic bounds versus deterministic bounds (*e.g.,* a receiver dynamic range certification requirement). Moreover, radio propagation is highly variable and radio waves are ''polarized'' and ''directional'' creating more statistical uncertainty. Further, technology advancements such as 5G Advanced Antenna Systems (AAS) enable more effective ''directionality'' to optimize wireless network coverage and performance, but technologies such as AAS also pose a dimension of uncertainty (*e.g.,* RF emissions 'below the horizon' versus 'above the horizon'). How can these probabilistic variables be accounted for in analyses to produce trusted results agreed upon by interested parties? Can a standard methodology and modeling tools be used to implement these processes?

The Commission also seeks comment on whether a standard reporting or measurement scale can be developed to categorize levels of interference or impairment. For example, most people are familiar with the Fujita (tornadoes), Saffir-Simpson (hurricanes), and Richter (earthquakes) scales, that stratify the consequences of undesired environmental effects in a manner that is understandable by the public. Can something similar be developed for spectrum and RF interference? Currently, some parties point to a relative change in the noise floor as a single indicator of harmful interference. However, given the orders of magnitude of variation between transmitter and receiver impairment conditions for different services and situations, a single-value relative change metric may not be meaningful. Moreover, under a harm claim threshold approach, there should be flexibility to determine a range of relevant values and associated responsibilities or ability to claim inference protection. Should the Commission establish a few basic and standard reference categories of interference, to enable quantitative/statistical risk assessment? As with the examples above, the absolute values of the scale can be different between different radio services. There is no ''one size fits all.'' However, the notion here is that ''sizes'' (or ranges of power) are potentially describable and more meaningful to the public. What categories and levels do commenters believe would be both easy to describe and lend relevance to this approach?

The Commission seeks comment on how a harm claim threshold could be enforced given the spatial and temporal

variations of various radio systems. The Commission seeks comment on how persistent and intermittent interference would or could be detected, reported, and used to identify a ''claim'' of interference? How would such a process distinguish external sources of interference from self-interference sources such as ''cross coupling'' between the transmit and receive paths within a radio transceiver, which could be misinterpreted as interference from an external source? How would sources of intermodulation interference be detectable and analyzed to distinguish (a) intermodulation interference generated from within a receiver, from (b) intermodulation products from the receiver's antenna system, from (c) intermodulation interference from the local environment (*e.g.,* rusty bolts, corroded metal infrastructure nearby), from [d] intermodulation interference generated from high power nearby RF emissions (*e.g.,* fundamental signals F_1 and F_2 can create interference at $F_3 = 2 * F_2 - F_1$) when impressed on a nonlinear element can cause co-channel interference within a receiver? The Commission seeks comment on these and other relevant interference reporting processes and best-practices that can be employed for specific radio services, regardless of whether receiver performance minimum expectations are established by industry standards or harm claim threshold methods. What other factors need to be addressed to effectively enforce a harm claim threshold? Commenters should be specific regarding what they and industry stakeholders can proactively and specifically do, and what role the Commission should undertake to enforce a harm claim threshold approach, especially in maintaining a ''light touch'' regulatory approach.

Finally, the Commission inquires about whether a harm claim thresholds approach should be expected to evolve as receiver performance improves over time. Should receivers that may meet a standard when they are deployed be upgraded or replaced in the future to merit interference protection under the Commission's rules if new receiver standards are developed that provide increased interference immunity? The Commission notes that different systems have different expected lifecycles. The Commission requests comment on whether it should consider a specified time frame from the date a receiver was deployed after which it should be expected to meet newer standards. Similarly, the Commission invites comment on whether limits should be reevaluated periodically and adjusted based on newer technology standards and capabilities, or whether receiver protection should be tied to certain required maintenance or replacement schedules.

Receiver Performance Mandates

As noted above, the Commission has not generally imposed requirements on receiver performance and relies instead on establishing technical and operational rules associated with transmitters. As to receiver performance, the Commission has relied largely on market forces rather than mandatory requirements to provide incentives for manufacturers to produce equipment with good receivers, though better performing receivers may come with increased cost. As discussed above, there have been a number of occasions in which the Commission has adopted rules that either promote receiver performance or require that receivers meet certain minimal technical performance capabilities, including situations involving repurposed spectrum where receiver performance specifications were required for future operations (DTV tuner requirements), developing acceptable levels of in-band and adjacent band interference for services (800 and 900 MHz bands), and safety-of-life services (maritime and location services). Some commenters or studies have indicated that in certain types of situations rules promoting receiver performance may be appropriate, such as in the case where the licensee does not have sufficient control over receiver performance.

Discussion. The Commission requests comment on whether and under what circumstances it might be appropriate for it to consider adopting rules promoting receiver performance or specifying minimal receiver requirements. The Commission also invites comment on possible regulatory approaches that promote receiver performance without specifying technical requirements.

The Commission seeks comment on whether it should consider expanding its receiver rules to encompass more radio services or to apply rules generally across all radio services. To what extent to do the Commission's limited existing requirements on receivers provide guidance as it considers this issue? How successful were those efforts at balancing the need for a rule requirement without imposing undue costs that might be associated with such a regulatory approach? Should a particular approach already adopted by the Commission for one particular situation be appropriate for considering in an analogous situation? Are there particular services or situations today that suggest that the Commission should consider adopting a rule on receiver performance to serve the public interest? Why would such an approach be appropriate?

If a commenter suggests that the Commission should consider adopting a rule requirement in particular situation(s), it seeks comment on why and how the rules could be applied. How specific would the requirements need to be? For example, the Commission could take a light touch regulatory approach and simply require equipment to meet certain industry standards or it could require receivers to meet certain benchmarks or a combination of the two based on radio service or type of equipment. Because some Commission licensees, such as mobile phone providers approve and certify specific phone models for use on their networks, should the Commission consider whether to adopt a requirement that those licensees ensure that their customers' equipment meets some minimal standards (*e.g.,* 3GPP standards)? Would a rule specifying such a requirement suffice? Or would specific minimum benchmarks be needed?

The Commission seeks comment on whether there are certain cases where a regulatory approach should be considered because the receivers associated with a particular service are not sufficiently under the control of the licensee or may not be designed to meet particular industry specifications. The Commission notes, for instance, that in many cases consumers have a wide variety of equipment choices (*e.g.,* in-home access point equipment, devices for use with a licensed or unlicensed services such as radar or satellite receivers), and the purchase decision is entirely in the consumer's hands without any licensee providing the role of gatekeeper on receiver performance. Would regulatory requirements to ensure minimal performance be appropriate in certain situations such as those? What are the costs and benefits of such an approach? Commenters should provide detailed justification for what type of requirements should apply to which services or user classes, if the Commission were to consider amending its rules to implement receiver requirements.

To what extent might it be appropriate for the Commission to consider requiring certain disclosure to consumers, and owners/operators of equipment and systems with embedded receivers or transceivers, so that they make a more informed choice about the equipment they purchase. The

Commission invites comment on whether it should require radio equipment information disclosure, for example through a labeling requirement, or key metrics regarding the receiver. Would such a requirement be useful to consumers and owners/operators of integrated systems that employ receivers? If so, what type of information would be most helpful to inform consumers and operators to make an educated decision (*e.g.,* selectivity, dynamic range, etc.)? Would such a requirement be beneficial across the board for all equipment or only for equipment designed for certain services or user bases? What would be the best way to disclose this information (*e.g.,* on packaging, in the manual, etc.)? What burden and costs would a disclosure requirement place on manufacturers? Would this increase product costs? If so, by how much? Commenters should provide details regarding who would benefit most from such disclosures and for what type of equipment for which rule parts or portions thereof. The Commission also seeks comment on how, if it deems such rules are warranted, they should be enforced? Should it be part of the equipment certification process where the Commission already imposes certain labelling requirements? Finally, the Commission asks if such a disclosure requirement would incentivize manufacturers to build better receivers? Are there any other factors or policy issues that the Commission should consider as it pertains to the potential for requiring receiver labeling information?

If the Commission were to pursue consideration of possible mandatory requirements, it requests comment on possible technical specifications or other requirements that would need to be considered. For example, could the rules tie a filtering requirement to the expected emissions in adjacent or nearby bands to ensure resiliency from out-of-band emissions or blocking interference? What about requirements regarding to spurious emissions or intermodulation interference? How could such requirements be implemented? What factors should go into determining such filter and other requirements? Is there a frequency separation that should be considered, either absolute or as a function of bandwidth that should be considered to adequately protect receivers against blocking interference? Should there be a required margin built in, to future proof receivers against future Commission actions that might affect the nearby RF environment? If so, how much of a margin is realistic? What issues need to be considered that affect the attenuation roll-off performance of filters? How should such requirements be contemplated for differing operational requirements (*e.g.,* requirement differences in fixed, mobile, satellite, broadcasting, radiolocation services, etc.)?

In the event a regulatory requirement is considered, the Commission seeks comment on what consideration should be given for services where the expected equipment lifetime differs. For example, certain industrial equipment is expected to work for 10 or 20 years or more while consumer mobile devices are typically replaced every few years. What other technical requirements would need to be specified? How should different receivers be categorized? Can a rating scale be developed to easily assess how much additional interference protection one receiver may have over another? Should any categorization be tied to characteristics of the desired transmitters? Or the undesired transmitters in adjacent and nearby bands?

In addition, the Commission seeks comment on how rules specifying particular receiver protection criteria may affect receiver architecture, particularly concerning implementation complexity, size, performance, form factors, number of external components, power consumption, impacts on other systems, and cost.

The Commission seeks comment on what type of tests may be needed if it were to consider specific requirements. Should such testing be part of the equipment approval process? Which receiver parameters should be examined? How should tests for these parameters be designed and conducted? Commenters should provide information regarding specific test details. Is there other information the Commission should consider, if it were to implement rule requirements for all or certain receivers?

Finally, the Commission requests comment on any other regulatory approaches the Commission should consider that would promote improved receiver interference immunity performance where that would be appropriate. The Commission asks that commenters provide sufficient explanation of their ideas and rationale for why they would be appropriate for consideration of such a regulatory approach as the best means of promoting its goal of promoting more efficient use of spectrum through improved receiver performance.

Innovation and the Marketplace

As part of the Commission's overall spectrum management goals, the Commission seeks to promote innovative new technologies and uses of spectrum. The Commission requests that commenters address the various considerations and approaches that have been discussed in this document, and inform the Commission about how best to promote innovation.

The Commission recognizes that receiver interference immunity performance specifications have the potential to impact receiver markets in various ways depending on how they are implemented. As discussed above, the Commission is examining three general types of approaches to promoting improved receiver performance—promoting industry-led voluntary approaches, providing additional Commission guidance, and possibly adopting mandatory requirements, or some combination of each. The Commission inquire as to how innovation and the marketplace would be affected by the approaches it is considering, and how best to consider the weighing of each approach as well as a balanced combination.

The Commission notes, for instance, that receivers with improved interference immunity performance features may create product differentiation that is generally desirable for consumers/users. As for voluntary approaches, voluntary industry guidelines and standards that promote development of receivers that are better or more desirable would create product differentiation. At the same time, however, the cost of producing such receiver devices might be higher than the cost of producing less resilient receivers, resulting in higher prices. In such a case, consumers/users would ultimately determine whether the receivers with greater interference immunity are ultimately deployed (compared to less resilient receivers), and would generally be based on whether the users would be willing to pay any higher prices that might be charged. The Commission seeks comment on how it might assess voluntary approaches in the context of innovation and the marketplace, and which approaches would be most or least effective when it comes to facilitating innovation while promoting improved receiver performance.

The Commission next seeks comment on how the various approaches discussed regarding potential Commission guidance would affect innovation and the marketplace. The Commission asks that commenters

address particular types of potential its policy guidance discussed herein—including general policy guidance, a policy statement, or an interference limits policy such as harm claim thresholds—and how those particular approaches affect innovation and the marketplace. Which approaches would be most or least effective as to facilitating innovation while promoting improved receiver performance? For instance, would clarification of Commission policy as to the integral role that receiver interference immunity performance plays in spectrum management, and clearer guidance about receiver responsibilities associated with developing and deploying receivers that protect against adjacent and nearby spectrum uses, help promote innovations in improved receiver design, and how should the Commission consider crafting such guidance in order to promote innovation in the marketplace? The Commission also notes that proponents of the development of an interference limits policy or harm claim threshold approaches note many benefits of such an approach, including that it could serve as a better alternative to adopting particular mandatory requirements in the rules. The Commission invites comment on how an interference limits policy or harm claim thresholds approaches affect innovation and the marketplace.

The Commission also invites comment on the adoption of regulatory requirements or rules (including standards) that require minimal levels of receiver interference immunity performance as the means for achieving its public interest goals. The Commission notes that mandatory standards would be expected to ensure development and deployment of receivers with a minimal level of interference immunity performance that would help achieve particular Commission goals regarding particular spectrum bands, including addressing issues relating to enabling greater access to adjacent band spectrum for other spectrum users. At the same time, the Commission notes that there may be instances in which regulatory adoption of specification standards could stifle innovation by restricting the introduction of products with otherwise desirable new features that are inconsistent with the standards, or might not be the most efficient at achieving the Commission's goals for ensuring a minimal level of receiver performance. The Commission asks for comment on how particular mandatory approaches may affect innovation and the marketplace. If a class of receivers are expected to be protected without a minimum knowable level of self-protection (selectivity) designed-in the receiver, how can protection be ensured?

With regard to each of the approaches discussed above, the Commission requests comment on the impacts of receiver interference immunity performance as to the following questions. What effects would interference immunity performance specifications have on innovation in equipment design, performance (especially as to performance not addressed by specifications) and features? What effects would particular approaches have on receiver markets in terms of cost of production, price and availability of equipment, and user demand? What aspects of specifications would have the greatest impacts on innovation and markets and what steps could be taken to minimize or mitigate their impacts? Since receiver filters to block OOB signals are generally a small fraction of the cost and complexity of a receiver, and generally, such components do not constrain the high-level innovative functions of a receiver, commenters should be specific and describe the impact on innovation, if any, of establishing basic minimum power reception limits from signals outside of a receiver's allocated spectrum band. Finally, to what extent should assessments of the impact on innovation and markets be a factor in the Commission's consideration of the various approaches for promoting improved receiver interference immunity performance discussed in this document?

In addition, the Commission inquires as to how it might evaluate an appropriate mix or balance among the various approaches that are discussed in this document as regards innovation and the marketplace. Commenters should offer their views on how the Commission might find that appropriate mix or balance. The Commission also invites comment on how these approaches might affect innovation in spectrum utilization. For example, how might these measures affect the development and costs and benefits of innovation associated with new wireless use cases? Compared to the Commission's approach to receiver performance to date, how might any of the approaches discussed above potentially serve to promote innovation in spectrum use, including not only in receiver but in transmitter design and performance as well?

Finally, the Commission invites comment on any other considerations that it should take into account on how best to promote innovation as it evaluates possible approaches to promoting improved receiver performance as part of its spectrum management in the future.

Legacy Receivers and Transition Pathways

There are many billions of receivers currently in use in various different radio services for a multitude of purposes. Depending on the types of approaches that industry and the Commission might take into promoting improvements in receiver performance, many of these existing ''legacy'' receivers may be impacted. Many receivers presumably already operate efficiently and include robust interference immunity, whether it is because they comply with voluntary industry guidelines, manufacturer designs are efficient, regulatory requirements are in place, or for other reasons. Many other receivers may currently not include the latest technologies or designs that could make the receivers more immune to interference, but also may be in the process of being replaced fairly quickly over the next few years, as is the case for consumer mobile devices over generally a five to ten year period. Then there are receivers in many different services, that may not be as immune to interference as they could be, particularly insofar as the receivers (or some subset of them) used in a particular service may be susceptible to interference from other operations in adjacent or nearby bands, or could experience interference with the introduction of new services in adjacent or nearby bands, in part because these receivers (or some subset of them) have not been designed to be more immune to interference.

As the Commission observed in its 2003 NOI on receiver performance, in situations where the Commission adopted spectrum policies that assumed receivers performed in accordance with a given set of interference immunity specifications, it is likely that many of the existing receivers could continue to provide satisfactory service. Further, interference conditions that would necessitate the use of receivers meeting the applicable guidelines/standards would not be present everywhere, and they may operate in locations where potentially interfering signals were not present or were present at levels within the capabilities of existing receivers. Such receivers could provide satisfactory service in many situations where industry or the Commission adopted spectrum policies that promote

receiver performance. Accordingly, the NOI noted that one approach would be to simply allow users to change to new receivers as they encountered interference. The Commission also identified another situation, such as where the service would be of more critical importance, and suggested that it might be necessary to require replacement of receivers, including the case in which a transition is being mandated for the replacement of receivers. The Commission asked about how to treat existing receivers that do not comply with any new receiver immunity specifications that may be developed, and how the size of the installed receiver base should affect development of receiver guidelines/standards, what criteria should be used by the Commission if it were to take action to require replacement of receivers (either rapidly on a transitional basis) in particular services, and what would be an appropriate phase-in period.

Regarding the potential replacement of legacy receivers, the GAO report noted both the lack of predictability about the future spectrum environment, and that it can take significant time and effort to upgrade and replace receivers once deployed. Silicon Flatirons suggested that it would be helpful if regulators could better anticipate the needs at band edges and provide proper notice (*e.g.,* 10 years) regarding the need for better receivers, and further noted that in order to help manage costs development of a phase-in of receiver regulation would be important. CSMAC discussed the need for future spectrum planning to give due consideration to legacy equipment and not to unnecessarily strand such equipment due to new services or devices that cause interference. It believed that when developing future spectrum sharing policies and considering technological advancements that enable improvements in legacy equipment, spectrum managers should also consider the replacement rate of existing transmitting and receiving equipment. This would avoid the potential for unnecessary stranded investment in this equipment, and balance the cost of this investment with the public benefits of more spectrum access to both Federal Government and other users.

The Commission further notes that the matter of how best to address legacy receivers and transition to less susceptible receivers in order to allow new operations in adjacent or nearby bands continues to be an important consideration as it seeks to enable new uses of spectrum and promote more efficient use of spectrum. The Commission anticipates that issues concerning legacy receivers that are not as interference-resilient as they could or should be may continue to arise, and consideration to potential pathways for addressing legacy receivers and any transitions to better performing receivers is important.

Discussion. What is the state of receiver performance across the commercial sector, including public safety, aviation and maritime safety, and Federal spectrum users? The Commission requests comment and suggestions on the range of issues and considerations that it should take into account as it considers the treatment of existing receivers that may not comply with any new approaches or policies adopted in the future (*e.g.,* improved receiver minimum interference immunity performance where that might be appropriate). The Commission notes that the issues include those relating to how it or others might determine the size of the installed base and identify existing or legacy receivers that potentially may be subject to approaches that lead to improved interference immunity performance. As discussed above, the Commission recognizes that in many instances, receivers are replaced fairly often, and that improved receiver performance in those cases could be achieved in a relatively rapid fashion, while there may be other situations in which other approaches (as discussed herein) may be appropriate. The Commission invites comment on each of these types of situations, including specific comment on whether and how to factor in the anticipated useful life of existing receivers.

The Commission also requests comment on considerations that it should take into account related to transitions (*e.g.,* repair or replacement) from use of legacy receivers to receivers that are more interference-immune in situations where that is deemed appropriate. Are there, for instance, particular approaches in previous or current Commission proceedings that provide some guidance that the Commission should consider? What are the complexities of introducing receiver requirements or harm claim thresholds in bands with existing spectrum allocations and service rules? What are realistic timelines for products in existing bands to adapt to a harm claim threshold or other regulatory actions to improve receiver performance? The Commission invites broad comment on relevant issues pertaining to legacy receivers and potential transition approaches, including timelines for transitioning that may be appropriate, the impact on global competitiveness, and consideration to regulatory actions that other nations have taken. Are there approaches that the Commission should consider that would enable smooth transitions? Should the Commission consider approaches that could facilitate any transition deemed appropriate that would minimize the costs that would be incurred? In sum, the Commission asks that commenters help it identify and consider the range of issues and concerns that should be taken into account with regard to addressing legacy receivers and transitioning to systems with improved receiver interference immunity performance that would serve the public interest.

Costs and Benefits

There are both costs and benefits that are associated with the implementation of the various approaches discussed in this document for the Commission's consideration as it seeks to promote improved receiver interference immunity performance in appropriate ways. The Commission recognizes that there could be a range of tradeoffs to consider. The Commission invites comment on ways to minimize the costs, optimize the benefits, and otherwise balance the costs and benefits, as steps are taken in the future to improve receiver interference immunity performance as part of its overall spectrum management goals in those situations in which doing so would serve the public interest.

The Commission notes that the TAC, in its *White Paper on Risk-informed Interference Assessment,* recommended that it include in its decision-making evaluation a quantitative risk-informed interference assessment (*e.g.,* comparing various likelihood/consequence combinations for multiple different potential interference hazard scenarios among the potentially affected operators) as it considers the interests of incumbents, new entrants, and the public. Others have noted that better understanding of the costs and benefits associated with improved receiver interference immunity performance could be help ''inform how to develop an incentive structure that would actually improve receiver selectivity.'' CSMAC indicated that in considering costs, spectrum managers should take into account changes and improvements in legacy equipment that will occur in the marketplace, and try to minimize the cost of stranded investments. Several other reports have focused on considerations related to the costs associated with any new guidance or policy promoting improved receiver performance, and discussions of the

need for an appropriate phase-in depending on the situation.

Discussion. The Commission invites comment on how it should consider the associated costs and benefits of the various approaches that are discussed in this document for promoting improved receiver interference immunity performance—including voluntary approaches, Commission guidance (*e.g.,* policy clarification, policy statement, interference limits policies), or regulatory approaches such as adoption of mandatory requirements for specified services.

The Commission also invites comment on how it might consider a phased-in approach when promoting improved receiver interference immunity performance in particular bands. As the Commission considers costs and benefits, what are the kinds of costs and the kinds of benefits that should be considered? The Commission asks that commenters discuss not only financial impacts but also considerations relating to competition as well as public safety and national security concerns. For example, would improvements in receiver interference immunity performance (*e.g.,* selectivity to reject unwanted emissions) enhance the ability of receivers to reject jamming and spoofing attempts? How might the Commission best consider the trade-offs concerning potentially affected stakeholders?

Legal Authority

As the Commission considers possible approaches to explore further, it seeks comment on its legal authority concerning the kinds of approaches it may be considering. In the 2003 *NOI on Receiver Performance Specifications,* the Commission stated its belief that it had the ''necessary statutory authority to promulgate receiver immunity guidelines and standards under sections 4(i), 301, 302(a), 303(e), (f), and (r) of the Communications Act, as amended.'' Several commenting parties generally agree, while others suggested that the Commission's authority could be limited.

Discussion. The Commission continues to believe that it has the necessary statutory authority to promulgate receiver immunity guidelines and standards under sections 4(i), 301, 302(a), 303(e), (f), and (r) of the Communications Act, as amended. The Commission requests comment on the assessment of its authority. The Commission also invites comment on other sources of authority as it considers the various approaches concerning receiver performance as discussed in this document. The Commission seeks comment in this document on whether the extent and limits of its statutory authority and enforcement mechanisms should affect its consideration of the possible approaches.

The Communications Act provides it with broad spectrum management authority, including authority under Title III of the Act to manage the use of radio spectrum and to prescribe the nature of wireless services to be rendered. In particular, section 303(e) allows the Commission to ''regulate the kind of apparatus to be used with respect to its external effects and the purity and sharpness of the emissions from each station and from the apparatus,'' section 303(f) directs the Commission to ''[m]ake such regulations not inconsistent with law as it may deem necessary to prevent interference between stations and to carry out the provisions of the chapter,'' and section 303(r) provides the Commission with general rulemaking authority. In the past, the Commission has drawn on its authority under section 303 to adopt requirements designed to protect receiving devices from interference from incoming signals by defining the conditions that constitute interference, including the operating parameters of the equipment causing and receiving the interference. For example, as discussed above, in both the 800 MHz public safety service and 900 MHz Business and Industrial/Land Transportation (B/ILT) service the Commission adopted regulations that required licensees claiming protection from unacceptable interference to use receivers capable of distinguishing wanted signals from unwanted signals. More recently, the Commission adopted rules for commercial use of the 3.5 GHz Band that included protection limits afforded to receivers, although in that proceeding the Commission found it was unnecessary to mandate receiver performance specifications.

In addition to the Commission's clear authority to regulate receivers by defining the conditions that constitute interference, the Title III mandate to prevent interference ''between stations'' may also authorize it to regulate the operations of a receiving station with respect to its compliance with technical parameters designed to ensure that it is capable of screening out certain levels of RF energy that would otherwise interfere with its reception of desired signals. The Commission invites commenters to provide an assessment of the extent of its Title III authority over receivers. Can section 303(f) be interpreted to authorize the regulation of *either* the transmission or reception of the undesired signal in order to prevent interference? Does section 303(f), together with sections 4(i), 301, 302(a), 303(e), and (r), provide a sufficient basis for the Commission to establish interference protection rights for licensees or other authorized users of licensed devices, contingent on their devices meeting certain threshold performance requirements? Do these or other statutory provisions also provide authority for the Commission to adopt requirements that specify interference-rejection capabilities for wireless receivers or to impose direct controls on receiver devices that lack sufficient capacity to reject incoming interfering signals? Are such regulations reasonably ancillary to the Commission's broad authority to ensure efficient use of radio spectrum? Prohibiting the manufacture or use of devices that are particularly susceptible to interference would prevent interference under the terms of section 303(f), insofar as that provision empowers the Commission to adopt regulations to prevent interference ''between stations.'' If Congress had intended to limit the Commission's authority to the regulation of the *transmission* of the undesired signal, it could have made that intent clear by stating in section 303(f) that the Commission has authority to adopt regulations to prevent stations from ''causing interference to other stations.'' By using the phrase ''between stations,'' however, Congress arguably provided the Commission with the flexibility to address interference problems at both the transmitting and receiving ends. Do commenters agree? The Commission seeks comment on the scope of the statutory definition of ''stations'' in the context, including how to interpret the definition of ''radio communication'' or ''radio transmission of energy,'' the former of which includes ''all instrumentalities, facilities, apparatus, and services (among other things, the receipt, forwarding, and delivery of communications) incidental to such transmission.''

What is the Commission's authority to impose direct regulation on device manufacturers—*i.e.,* to prohibit the manufacture or marketing of devices that fail to conform to minimum performance standards for resisting interference? Section 302(a)(2) of the Communications Act gives the Commission authority to ''establish[ ] minimum performance standards for home electronic equipment and systems to reduce their susceptibility to interference from radio frequency energy'' and provides that ''[s]uch regulations shall be applicable to the manufacture, import, sale, use, offer for

sale, or shipment of such devices and home electronic equipment and systems, and to the use of such systems.'' While the Commission has clear authority to adopt performance standards for receivers used as home electronic equipment under section 302(a)(2), the Commission seeks comment on the scope of the Commission's authority pursuant to the provision. To what extent does the Commission's authority extend to receivers used in commercial applications, such as on airplanes, commercial delivery trucks, or tractors on industrial-scale farms? Can consumer-facing devices used outside of the home, such as GPS devices used as navigation aids, be regulated under the authority?

The Commission invites comment on any other sources of authority it could rely on for the actions it considers here. Commenters should explain in detail why they do or do not believe the Commission have authority to act if it chooses to do so. Commenters should also address whether the kinds of efforts or approaches that the Commission may ultimately take (*e.g.,* gathering more information on receiver characteristics, developing and implementing harm claim threshold approaches, requiring transitions) would affect the analysis of the Commission's authority or of its ability to enforce its rules effectively.

Other Possible Approaches and Issues

The Commission invites comment on other possible approaches for its consideration. For instance, would convening Commission-led workshops comprised of a variety of experts from industry and government be helpful? Would any pilot project be appropriate, and if so, with what particular frequency band(s) should be considered. Are there further studies that could help inform the Commission on important considerations with regard to improving receiver interference immunity performance? Are there other studies, efforts, analyses that the Commission should consider in the proceeding? If so, the Commission asks that commenters identify them and explain why they should be considered.

Digital Equity and Inclusion. Finally, the Commission, as part of its continuing effort to advance digital equity for all, including people of color, persons with disabilities, persons who live in rural or Tribal areas, and others who are or have been historically underserved, marginalized, or adversely affected by persistent poverty or inequality, invites comment on any equity-related considerations and benefits (if any) that may be associated with the various approaches and issues discussed herein. Specifically, the Commission seeks comment on how the various approaches that it may consider may promote or inhibit advances in diversity, equity, inclusion, and accessibility, as well the scope of the Commission's relevant legal authority.

Procedural Matters

Ex Parte Rules. The proceeding shall be treated as a ''permit-but-disclose'' proceeding in accordance with the Commission's *ex parte* rules. Persons making *ex parte* presentations must file a copy of any written presentation or a memorandum summarizing any oral presentation within two business days after the presentation (unless a different deadline applicable to the Sunshine period applies). Persons making oral *ex parte* presentations are reminded that memoranda summarizing the presentation must (1) list all persons attending or otherwise participating in the meeting at which the *ex parte* presentation was made, and (2) summarize all data presented and arguments made during the presentation. If the presentation consisted in whole or in part of the presentation of data or arguments already reflected in the presenter's written comments, memoranda, or other filings in the proceeding, the presenter may provide citations to such data or arguments in his or her prior comments, memoranda, or other filings (specifying the relevant page and/or paragraph numbers where such data or arguments can be found) in lieu of summarizing them in the memorandum. Documents shown or given to Commission staff during *ex parte* meetings are deemed to be written *ex parte* presentations and must be filed consistent with Rule § 1.1206(b), 47 CFR 1.1206(b). Participants in the proceeding should familiarize themselves with the Commission's *ex parte* rules.

Comment Filing Procedures. Pursuant to §§ 1.415 and 1.419 of the Commission's rules, 47 CFR 1.415, 1.419, interested parties may file comments and reply comments on or before the dates indicated on the first page of the document. Comments may be filed using the Commission's Electronic Comment Filing System (ECFS) or by paper. All filings must be addressed to the Commission's Secretary, Office of the Secretary, Federal Communications Commission.

- *Electronic Filers:* Comments may be filed electronically by accessing ECFS at *https://www.fcc.gov/ecfs.*
- *Paper Filers:* Parties who choose to file by paper must file an original and one copy of each filing. Paper filings can be sent by hand or messenger delivery, by commercial overnight courier, or by first-class or overnight U.S. Postal Service mail.
- Effective March 19, 2020, and until further notice, the Commission no longer accepts any hand or messenger delivered filings. This is a temporary measure taken to help protect the health and safety of individuals, and to mitigate the transmission of COVID–19.
- Commercial overnight mail (other than U.S. Postal Service Express Mail and Priority Mail) must be sent to 9050 Junction Drive, Annapolis Junction, MD 20701.
- U.S. Postal Service first-class, Express, and Priority mail must be addressed to 45 L Street NE, Washington, DC 20554.

Availability of Documents. Comments, reply comments, and *ex parte* submissions will be publicly available online via ECFS. These documents will also be available for public inspection during regular business hours in the FCC Reference Information Center, when FCC Headquarters reopen to the public.

People with Disabilities. To request materials in accessible formats for people with disabilities (braille, large print, electronic files, audio format), send an email to *fcc504@fcc.gov* or call the Consumer & Governmental Affairs Bureau at 202–418–0530 (voice), 202–418–0432 (tty).

Ordering Clauses

Accordingly, *it is ordered* that, pursuant to sections 4(i), 301, 302(a), 303(e), 303(f), and 303(r) of the Communications Act of 1934, as amended, 47 U.S.C. 154(i), 301, 302(a), 303(e), 303(f), and 303(r), the Notice of Inquiry *is adopted.*

Federal Communications Commission.

Marlene Dortch,

Secretary.

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