April 25, 2014

VIA ELECTRONIC MAIL

Honorable Fred Upton
Chairman, Energy and Commerce Committee
US House of Representatives
2125 Rayburn House Office Building
Washington, DC 20515

Honorable Greg Walden
Chairman, Communications and Technology Subcommittee
Energy and Commerce Committee
US House of Representatives
2125 Rayburn House Office Building
Washington, DC 20515

Dear Chairman Upton and Chairman Walden:

The GPS Innovation Alliance is pleased to submit the attached comments responding to the Committee's questions on spectrum policy. Thank you for the opportunity to present our views on these important issues. We look forward to working with the Committee and its staff.

Sincerely,

James A. Kirkland
President

6. The FCC's existing process manages spectrum use through allocation and assignment—bands are allocated for specific services or classes of users, and licenses for use of specific portions of spectrum are assigned to entities. Many of the existing allocations were made because certain spectrum bands are better suited for certain uses. However, changes in technology have changed assumptions over the years. While restrictions have eased in recent years, there are still certain limited-use spectrum licenses. Flexible use licenses permit licensees to use their spectrum for any service, including wireless, broadcast, or satellite services. Should all FCC licenses be flexible use? In what instances should the Commission exercise control over the service offered? How can the Act enable better use of spectrum, either flexible or specified?

While not expressly defined, "flexible use" is described anecdotally in an FCC Technical Advisory Committee White Paper as contemplating cellular network architectures with the operational characteristics that accompany cellular networks – very high-power base stations communicating with portable or handheld devices.[1] In other words, the technical rules around flexible use will permit uses up to and including high power mobile network downlinks. Recent FCC discussion of spectrum issues has focused on the goal of maximizing the amount of "flexible use" spectrum, positing that "[t]o meet the rapidly increasing demand for wireless capacity, wireless systems must operate in ever closer proximity in frequency, space and time."[2/] While such a regime provides a great measure of freedom to the licensee who acquires flexible use spectrum, this flexibility comes at a cost to any adjacent spectrum holder, who will be expected to be able to accommodate the full range of permitted operations, up to and including very high powered operations. If the adjacent band use is not immediately compatible with high powered use, the TAC White Paper appears to suggest that adjacent spectrum holders will be forced to accommodate the use over time.[3]

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[1] *See*, *e.g.*, TAC White Paper. at 13 (explaining that licensees should assume "as a starting point that the adjacent band will be re-allocated for use as a cellular downlink"). *See, e.g.*, *id.* at 36 (discussing Kwerel & Williams recommendation that flexible use be defined as "a dense deployment of base, mobile and fixed transmitters operating at fully functional power levels typical of a modern wireless cellular architecture"); *see also* Kwerel, E. and Williams, J., "Solving the Receiver Problem Without Receiver Standards: FCC Workshop on Spectrum Efficiency and Receivers," March 13, 2012, *available at* http://transition.fcc.gov/bureaus/oet/receiver-workshop1/Session6/SESSION-6-1-Kwerel-Williams-FCC.pdf

[2/] *FCC Technological Advisory Council White Paper "Interference Limits Policy: The Use of Harm Claim Thresholds to Improve the Interference Tolerance of Wireless Systems," February 6, 2013, available at* *http://transition.fcc.gov/bureaus/oet/tac/tacdocs/WhitePaperTACInterferenceLimitsv1.0.pdf* at 5.

[3] This could be accomplished, for example, by permitting the flexible use licensee to increase power of operations over time through an increasing "harm claim threshold." Under a harm claim threshold approach, the adjacent band user would not be able to complain about interference below the progressively increasing harm claim threshold, so that it would effectively bear the burden of modifying its equipment and operations to tolerate the progressively high powered operations next door. *See TAC White Paper, Sec. 3.2(pg. 16) and Sec 5 (pg. 24).*

If this kind of flexible use regime were to become the default framework for licensing spectrum newly freed up for broadband use, there is a tremendous potential for inefficiency in spectrum use, unnecessary costs, and distortion of the development of the full range of technologies that require radio spectrum to operate. In order to see this potential, consider a likely scenario: the FCC is able to "clear" a frequency band for flexible use, but this band is adjacent to a band with existing users. The FCC phases in flexible use over time (say, five years), so that at the end of the phase-in period, the adjacent band licensee will be required to accommodate uses of the flexible use band up to and including high power mobile network downlinks. Even assuming such accommodation is technically possible, this regime, from its inception, imposes engineering and development costs on those who make devices for use in the adjacent band, since those device manufacturers will need to begin investing in changes to their equipment in order to ensure their devices will be in a position to accommodate high powered use in adjacent bands in five years. These investments may or may not prove to be necessary, since a flexible use licensee may, over time, decide not to deploy high powered mobile broadband downlinks in the relevant spectrum. There may also be hidden costs in forcing this change. For example, a spectrum-based technology that worked perfectly well when it did not have to be engineered to withstand high powered operations in the adjacent flexible use spectrum, may simply not work as well, or not work at all, under the new constraints. If flexible use becomes a common framework, the effect may be that spectrum-based technologies that cannot be engineered to accommodate high powered operations will never see the light of day, chilling potential investment and development. The costs of this will be entirely unknowable.[4]

The TAC White Paper simply assumes, without providing technical evidence, that with the right amount of time and some unknown level of investment in new technology or alternative product design, any spectrum use should be able to accommodate high-powered, cellular-like operations in directly adjacent spectrum. This assumption has not been thoroughly tested and validated, and based upon past

[4] It could be argued that licensees will be able to negotiate private transactions to rationalize their respective spectrum uses, so that unnecessary costs can be avoided in this manner. As an initial matter, however, one impetus to having a set of default rules around flexible use and corresponding interference rights or harm claim thresholds is to *avoid* reliance on privately negotiated transactions in order to permit spectrum use, so this would not appear to be an adequate safeguard. Moreover, as the TAC White Paper recognizes, there are common scenarios in which spectrum users may not be represented by a party that is capable of "negotiating" on its behalf, such as unlicensed users and users of "decoupled" receivers. In any case, the party holding flexible use rights will have superior "rights" to impose interference on adjacent band licensees who do not have flexible use rights, and so may extract an effective "tax" from adjacent band licensees in any private negotiation. It is not obvious why such a tax makes sense, and in any case it would similarly distort the development of alternative spectrum uses.

instances involving significant interference between dissimilar uses in close spectral proximity, may be unfounded. If the assumption is incorrect, adoption of a "zoning" and re-farming approach, which groups similar uses together (*e.g.*, low-power and satellite uses) is more appropriate and could actually produce more usable spectrum by, among other things, reducing the need for guard band spectrum and minimizing the number of band "edges" between dissimilar uses. In any case, before enshrining "flexible use" as the default authorization regime for spectrum across the board, the FCC and affected spectrum users must thoroughly analyze whether it will be technically feasible for the full range of spectrum uses to reasonably accommodate high-power cellular use in adjacent bands.

Premature Predictive Judgments Yield Bad Policy

Premature or overbroad application of "flexible use" in spectrum licensing also risks repeating the spectrum management mistakes of the past and wrongly perpetuating current technological and market circumstances well into the future, far beyond the horizons of predictability. Equating flexible use with high-powered cellular-based systems presumes that current technology for delivering mobile broadband will continue to predominate into the indefinite future. This view should be subjected to healthy skepticism. As a general matter, the FCC's ability to make predictive judgments about future technological developments is limited. That is why the FCC is generally reluctant to make technological mandates.[5/] In fact, the limitations of the FCC's ability to make predictive judgments are highlighted by the fact that an earlier set of technological predictions created the current spectrum conundrum. It is clear, but only in hindsight, that when the FCC first allocated spectrum for satellite use, it overestimated the need for satellite-based services. As a result, very successful and efficient satellite based uses (*e.g.*, GPS) sit side-by-side with satellite services that currently meet mainly niche market needs (*e.g.*, MSS).

In fact, there are already good reasons to doubt whether extrapolation of "flexible use," as currently conceived, to serve as the fundamental basis of spectrum policy in the future, is sound. It is already clear that low power Wi-Fi uses are an important part of the broadband wireless service ecosystem. In addition to providing the most common form of distribution of broadband services within

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[5/] *See, e.g.*, *Amendment of the Commission's Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz*, Report and Order, GN Docket No. 13-185, FCC 14-31, ¶ 105 (rel. Mar. 31, 2014) ("Mandating a particular industry standard such as LTE would hamstring innovation and development and be contrary to the Commission's policy to preserve technical flexibility and refrain from imposing unnecessary technical standards."); *Expanding Access to Broadband and Encouraging Innovation Through Establishment of an Air-Ground Mobile Broadband Secondary Service for Passengers Aboard Aircraft in the 14.0-14.5 GHz Band*, Notice of Proposed Rulemaking, 28 FCC Rcd. 6765, ¶ 101 (2013) (explaining that the Commission "strive[s] to establish technology neutral rules that allow for competing technologies and changes in technology over time").

the home, Wi-Fi, with its "offload" of traffic from carrier mobile broadband networks onto local area Wi-Fi networks, has become an increasingly important factor in overall carrier capacity planning. Recent forward looking studies also recognize that lower power, less centralized spectrum uses will assume increasing importance in the future.[6]

Flexible Use As Currently Defined May Be Incompatible With Important Spectrum Uses

While these concerns apply to spectrum uses generally, it is easy to see that particular kinds of technologies are more likely to be adversely affected by overly broad application of flexible use rights. The recent experience with LightSquared and GPS highlights the difficulties of coordinating high powered terrestrial operations with satellite uses in nearby spectrum, as discussed in the response to Question 9 on Receiver Standards. The fact remains that it was technically impossible for many GPS receivers to accommodate LightSquared's proposed deployment of high powered terrestrial mobile broadband downlinks and related uplinks in the bands adjacent to GPS.

The difficulties of coordinating flexible use, as currently conceived (high powered terrestrial transmissions), with satellite uses is cause for serious concern. In addition to GPS, two other highly successful spectrum uses are satellite based: direct-to-home satellite video and digital satellite radio. In the future, with the advent of the "internet of things" and the need to access to data literally everywhere (as opposed to the expansive but still limited footprints of high powered cellular based networks), it is not hard to imagine substantially increased demand for mobile services which take advantage of the ubiquitous coverage of satellites.

For example, autonomous vehicles require truly ubiquitous access to both satellite navigation and satellite communication signals (GNSS signals augmented for precision with satellite delivered corrections data). Motorists can currently tolerate lack of cellular coverage on long trips through lightly populated areas, since the worst case is the inability to make a call or access the internet for a limited period of time. The same cannot be said if your vehicle is relying on data signals for navigation, collision avoidance, and route optimization. While the FCC may have over-allocated spectrum for satellite

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[6] *Report to the President Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth*, Executive Office of the President, President's Council of Advisors on Science and Technology, at vi (July 2012) (noting an "important" trend that "instead of just the tall cell towers that provide coverage for very large geographic areas, many wireless services are already moving to 'small cell' operations that provide services for very small geographic areas, reducing the potential for interference so that other services may operate much closer to them. The huge explosion of Wi-Fi services is one example of this evolution.").

applications in the past, we respectfully submit that it is equally dangerous to swing the pendulum to the opposite extreme and assume that new high-value satellite services will not develop in the coming decades. Wholesale reallocation of spectrum near critical satellite uses such as GPS for “flexible use,” as currently conceived, rather than preserving appropriately sized “quiet neighborhoods” for satellite, is likely to prove a costly mistake.

9. As discussed above, interference can pose a major problem to efficient and full use of spectrum by providers. The FCC sets limits on transmissions, but doesn't regulate the receivers used by wireless devices to receive wanted signals and eliminate the noise coming from the other surrounding spectrum bands. Underperforming receivers can prevent a device from operating properly. While the FCC has used tools like guard bands to mitigate the potential for interference, recent examples of receiver overload have shown that these efforts may not be enough as demand for spectrum increases but resources become more and more constrained. Some have proposed receiver standards as a solution, but others argue that such a step could result in over-engineering and higher consumer prices. What is the best balance between mitigating interference concerns and avoiding limiting flexibility in the future? Can engineering and forward-looking spectrum strategies account for the possibility of unanticipated technologies and uses in adjacent spectrum bands? How do we promote flexibility without unreasonably increasing the cost of services and devices? Does the Act provide the FCC tools to address this problem?

Policy Pitfalls

Interference is indeed a major impediment to efficient use of spectrum. The potential for interference can both degrade valuable existing uses of spectrum and inhibit new high value uses. While there is certainly a compelling need to make underutilized spectrum available for new uses, or to add capacity for existing uses such as mobile broadband, changes in technical rules or policies affecting existing services to enable these new uses can impose costs and performance penalties to innovative and successful spectrum uses. The public interest requires that the costs and benefits of significant changes be weighed carefully, especially when there are considerable numbers of users who are dependent on an existing spectrum use. This can be extraordinarily difficult to do, and the FCC has struggled with structuring fact based processes with reasonable time frames and regulating with an appropriately long term perspective.

There has also been a natural tendency to view spectrum management issues through the prism of current market and technological circumstances, even though resulting decisions will shape market conditions and the development of technologies for decades. The current FCC priority of maximizing availability of spectrum for mobile broadband services delivered through a network of relatively high powered base stations requires caution: if long term spectrum management decisions are excessively weighted in favor of enabling spectrum uses with this highly centralized, capital intensive model, dissimilar but equally important spectrum uses could easily be penalized and alternative spectrum uses may be significantly hampered.[1]

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[1] *See* the discussion in response to Question 6. It is already clear that low power Wi-Fi uses are an important part of the broadband wireless service ecosystem. In addition to Wi-Fi's providing the most common form of distribution of broadband services within the home, "offload" of traffic from carrier mobile broadband networks onto local area Wi-Fi networks is an increasingly important factor in overall carrier capacity planning. Recent forward looking studies already recognize that lower power, less centralized spectrum uses will assume increasing importance in the future. *Report to the President Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth*, Executive Office of the President, President's Council of Advisors on Science and Technology, at vi (July 2012) (noting an "important" trend that "instead of just the tall cell towers that provide

The debate over the need to impose "receiver standards" on GPS devices, for example, well illustrates the difficulties inherent in spectrum management. Reducing the potential for interference between large scale, high power mobile broadband networks and other ubiquitous uses (such as GPS) presents formidable technical challenges, and given the ubiquity and importance of both technologies and their importance to our nation's economy, changes in policy and technical standards present unique risks of imposing unknown and unknowable costs, and distorting technological developments and beneficial innovation. Consideration of receiver standards in isolation from the broader challenges involved in reconciling these important spectrum uses could easily lead to bad spectrum policy decisions.

Technical Considerations

Managing potential interference between divergent spectrum uses is a very complex problem, requiring multiple levels of detailed engineering analysis. A few general parameters, however, tend to dominate the equation; namely, the relative technical characteristics of the uses (e.g. similarity or dissimilarity of transmitter power and receiver sensitivity between the systems), and the proximity of the uses in space (or geography) and frequency. Similar uses are easier to coordinate, while dissimilar uses are more difficult to coordinate to the extent that they are in adjacent or nearby frequency bands, and where transmitters and receivers are operated in close spatial or geographic proximity.

Two common scenarios illustrate the basic relationships. First, mobile carrier base station downlink transmissions can be proximate in frequency and have transmitters located on the same tower (be proximate in space), but can be operated together with relative ease in part because they have very similar technical characteristics (power levels, common timing, signal characteristics) and because there are longstanding engineering techniques for coordinated operation of such fixed facilities. High powered television or radio stations can operate on the same frequencies, if they have sufficient geographic separation. Even radio and television stations operating on different but proximate frequencies must be separated geographically to avoid interference to television or radio receivers.

In contrast, management of potential interference between carrier based mobile broadband operations and the reception of satellite to earth transmissions, such as GPS signals, as considered in the recent LightSquared proceedings, presents an entirely different and worst case scenario. First, the relative technical characteristics of the uses could not be more different. Mobile broadband downlink transmissions are very high powered relative to the satellite signals as received on earth – literally billions of times stronger. Even mobile broadband handset (uplink) transmissions can be billions of times stronger than GPS satellite signals as received on earth when a mobile handset is transmitting in close proximity to a GPS receiver (for example, when the passenger in the front seat of a car with a GPS navigation system is using his or her cell phone).

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coverage for very large geographic areas, many wireless services are already moving to 'small cell' operations that provide services for very small geographic areas, reducing the potential for interference so that other services may operate much closer to them. The huge explosion of Wi-Fi services is one example of this evolution.").

While the "undesired" (potentially interfering) mobile broadband signal is very strong, on the one hand, GPS receivers, on the other hand, must be extraordinarily sensitive to pick up the "desired" GPS signal. These divergent power levels make coordination between these systems exceedingly difficult due to the fact that GPS signals as received on earth are below the thermal noise floor (the level of noise occurring naturally and apart from manmade sources) which prevails in the GPS frequency band, and receivers perform an extraordinary engineering feat to extract the signals from the noise and then process them to provide accurate location information. To do this, GPS receivers must have extremely sensitive receiver front ends, employ extremely sophisticated signal processing functions, and utilize multiple signal processing stages, all of which are adversely affected by interfering "noise."

The proximity variables involved in avoiding interference between terrestrial and satellite services are as challenging as any the FCC has faced in the past. Spatially, mobile broadband networks must be effectively ubiquitous from a user standpoint – users will take mobile handsets everywhere, so uplink transmissions are ubiquitous, and carriers design their networks to have downlink cell coverage where the vast majority of the people are the vast majority of the time. GPS, which is almost exclusively a mobile spectrum use, has an even more ubiquitous footprint. GPS satellite signals are available nearly everywhere, and, with over a half a billion GPS devices in everyday mobile use in the US, including GPS receivers in almost every cell phone, GPS receivers will be in close proximity to fixed or mobile broadband transmitters the vast majority of the time.

Moreover, the effect of interference on a GPS device is also very problematic. Unlike interference between mobile communications networks, where the user can observe the results of interference in dropped calls or poor call quality, the positional accuracy of a GPS device can be degraded by interfering noise in a way that is not detectable, can mislead users about their location, and, in the case of automated guidance applications, may cause poor performance or outright malfunctions. In extreme cases of interference, where a GPS receiver "loses lock" on available GPS satellites altogether, the user is left with no means of determining location until the interference is abated. [2]

Case Study: LightSquared and the MSS Band

All of these factors were evident in LightSquared's attempt to use the Mobile Satellite Service for ubiquitous high powered mobile broadband. The international Radionavigation Satellite Service

[2] GPS is a navigation system and operates in a fundamentally different manner from radio communications systems. The primary measurement in GPS involves determination of the timing of bit transitions in the navigation signal, and precise positioning requires sub-nanosecond measurement of bit edges. This is a very different type of function from that typically performed by terrestrial communications receivers, and traditional means of analyzing and mitigating interference in the communications realm may have little relevance to GPS, or may adversely affect receiver performance. For example, terrestrial mobile networks can use techniques such as dynamic power control and can trade off communications speed and reception quality to maintain viable communications sessions. GPS receivers must work with satellite signals that are fixed in nature and make the most of the data that can be extracted from very low power signals buried in the thermal noise and any interfering signals.

("RNSS") allocation (where GPS operates) runs from 1559 MHz to 1610 MHz. LightSquared's MSS spectrum is directly adjacent to this spectrum, with downlink (satellite to earth or base station transmission in terrestrial operation) spectrum between 1525 and 1559 MHz and uplink (earth to satellite or handset transmission in terrestrial operation) between 1626.5 and 1660.5 MHz. LightSquared initially proposed to operate high powered base stations at 1545-1555 MHz, a mere 4 MHz away from the authorized receive band of GPS receivers. It should have surprised no one that this proposed operation caused massive and widespread interference to virtually every category of GPS receiver. No one has seriously argued that it is possible to engineer a broad range of reasonably priced, fully functional GPS devices that could both receive faint GPS satellite signals and also withstand such high powered broadband signals so close in frequency.[3] Both base station and handset transmissions in other portions of the MSS band have also been shown to cause interference to GPS receivers, and such operations require further technical study.

During the debate over LightSquared's proposals, LightSquared frequently claimed that the proven interference between LightSquared's proposed operations and GPS receivers was entirely the result of design characteristics of GPS receivers, which "listened" to LightSquared's frequencies. These characterizations are entirely inaccurate, and, from an engineering standpoint, effectively meaningless as well as misleading.[4] The FCC has long understood that receivers designed to receive one set of frequencies can be "overloaded" by transmissions in adjacent frequencies.[5] The risk is especially high when the difference between the power levels of the "desired" in-band signals and the "undesired" adjacent band signals is great and is even higher the closer the adjacent band signals are in frequency to the desired signals.

The issue of overload interference is not unique to GPS - in fact, virtually any radio receiver can be overloaded if the adjacent frequency signals are in close enough spatial and spectral proximity and the disparity in power is sufficiently great. GPS receivers are typically designed to withstand adjacent band transmissions hundreds of millions of times stronger than GPS signals, and compare favorably to

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[3] Even LightSquared has conceded that the 1545-1555 band is not usable for base station transmissions.

[4] This claim is literally true for a relatively small number of high precision GPS receivers which were designed to receive separate satellite based "corrections" services which were transmitted using LightSquared's satellite services, for which LightSquared happily collected revenue. However, LightSquared made this claim about all GPS receivers, a claim that is misleading and effectively meaningless for the reasons stated in text.

[5] *See, e.g.*, *Amendment of Part 27 of the Commission's Rules to Govern the Operation of Wireless Communications Services in the 2.3 GHz Band; Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band*, Report and Order and Second Report and Order, 25 FCC Rcd 11710 (2010) (evaluating the potential for overload interference to Satellite Digital Audio Radio Service receivers from Wireless Communications Service ("WCS") mobile devices and adopting conditions on WCS devices to help mitigate the potential for such interference); *Service Rules for Advanced Wireless Services in the 2155-2175 MHz Band*, Notice of Proposed Rulemaking, 22 FCC Rcd 17035, ¶ 16 (2007) (expressing concern with overload interference to adjacent channel mobile receivers from AWS-3 operations and proposing to limit the transmitting power of the AWS-3 mobile transmissions to protect such receivers).

other common types of mass market receivers. Recent carefully controlled tests conducted by Aerospace Corporation demonstrated that three typical GPS receivers were better able to withstand adjacent band transmissions, on a relative basis, than digital television and FM radio receivers from reputable television and radio manufacturers.[6]

The possibility of receiver overload and the need to provide spectral separation to avoid overload and protect receivers is routinely taken into account in spectrum planning in other contexts, including mobile services. One common example is the separation of downlink and uplink frequencies in paired mobile spectrum blocks used for frequency division duplex (FDD) mobile technologies, which are by far the most common form of mobile technology. FDD LTE frequency bands are paired to allow simultaneous transmission on two frequencies. The bands must have sufficient spectral separation in order to prevent the transmitted signals from unduly impairing the receiver performance. If the signals are too close in frequency, the receiver will be "blocked" and its sensitivity impaired. The separation between receive and transmit frequencies must be sufficient to enable the antenna and filters to sufficiently attenuate the transmitted signal within the receive band. As a result, the standard separation (or “band gap”) between paired uplink and downlink spectrum is significant, as shown in the attached list of LTE bands. In the case of GPS versus mobile downlink operations, the power differential is much higher than the mobile to mobile case, requiring even greater levels of separation than those required to protect mobile receivers under normal operating conditions.

In other words, there is no expectation in the mobile world generally that receiver filtering must be capable of tolerating high powered transmissions in closely adjacent spectrum in normal operations. This reflects a rational balancing of considerations of cost and sound engineering practice for devices (mobile handsets) that are aimed at the mass consumer market. When viewed in this context, it is clear that the susceptibility of GPS receivers to high powered transmissions in adjacent bands is in no way a “problem” with GPS receivers; rather, such a suggestion reflects either ignorance of basic engineering principles, application of a double standard to GPS receivers, or both. Adoption of receiver standards on this basis would be arbitrary and unfair to GPS, and would effectively hold GPS devices to a higher standard than other consumer electronic devices.

Receiver Regulation Should Not Be Considered in Isolation

Since multiple factors affect the likelihood of interference between highly dissimilar spectrum uses, focusing solely on regulation of receiver characteristics is likely to have limited usefulness and may very well be inefficient and harmful to continued innovation in affected spectrum uses. Forward looking receiver performance standards will not solve interference to existing receivers, and a mandated transition to upgraded receivers has clear costs which need to be weighed carefully. On the other hand, having clearly defined receiver protection criteria, which are soundly formulated on a technology neutral basis and which are forward looking in applicability, could enhance predictability in spectrum use. However, incremental improvements in receiver design are unlikely to substantially change

[6] T.D. Powell, “Adjacent Band Interference to Consumer Radio Receivers,” Aerospace Corporation Study No.TOR-2013-00046, May 2013.

receivers' susceptibility to interference in the case of highly dissimilar spectrum uses. More fundamental re-engineering of a successful receiver technology such as GPS to accommodate a highly dissimilar use is very likely to lead to losses in performance and a slower pace of innovation in the underlying technology due to the need to adapt designs to engineering challenges unrelated to the purpose of the devices in question.

Receiver regulation could also impede innovation. Determination of receiver standards by the FCC will be very difficult under any scenario, and administration and enforcement of these standards present formidable challenges, especially in the case of GPS.[7] Devices that use GPS for location based applications come in a great variety of form factors and support an immense variety of hardware devices and software applications that rely on GPS, from baseball sized precision devices to smart phones to tiny receivers embedded in watches or running shoes. As a result, design changes intended to mitigate interference from undesired signals, such as including more elaborate filtering, may be possible for some devices, but may simply be impractical for other applications. Over the long term, we believe that the public will be best served by allowing companies to innovate with a wide variety of form factors, rather than implicitly or explicitly requiring engineering changes which effectively limit when and how GPS receivers can be used.

Spectrum "Zoning" Can Provide a More Efficient Means to Avoid Interference

A more straightforward approach, and one which is more likely to be effective than exclusive reliance on mandated receiver standards, is to minimize the number of dissimilar spectrum applications in close spectral proximity to each other. Put another way, similar spectrum uses should be grouped together to the greatest extent possible to minimize the number of band edges or "border areas" where dissimilar uses in close proximity create serious interference challenges. Such an approach would involve more use of a "zoning" approach to spectrum management, as opposed to a "good fences make good neighbors" approach that requires the FCC to engage in extensive rule making and standards development to balance the interests of dissimilar spectrum uses in every border area.

Applying such a "zoning" approach to GPS and adjacent satellite spectrum bands would involve maintaining the historical "quiet neighborhood" and avoiding authorization of high powered uses in this band now or in the future.[8] This spectrum could be the target band for future satellite communications services and expansion of existing satellite services. If there is a long term need to relocate satellite uses from other bands to free up spectrum for terrestrial uses such as mobile broadband, or to address

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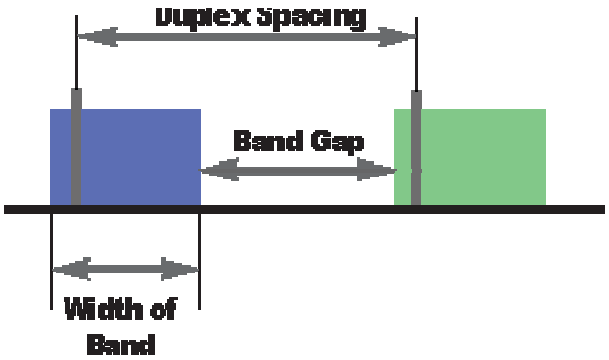
[7] For example, the "harm claim thresholds" approach recently proposed by the FCC, while it avoids the need for detailed regulation of receiver design, would be very difficult to implement. Comments of the GPS Innovation Alliance, ET Docket No. 13-101, at 16-22 (filed July 22, 2013) (explaining that harm claim thresholds present serious administrative challenges, particularly for "decoupled" devices such as GPS receivers).

[8] Reserving the Mobile Satellite Service band for satellite use would not prejudice existing spectrum rights since MSS license holders never had rights to use MSS spectrum for terrestrial purposes other integrated services to "fill-in" gaps in satellite coverage.

interference issues elsewhere, the FCC could utilize the satellite bands adjacent to GPS to consolidate such satellite uses.

LTE FREQUENCY BAND DEFINITIONS



FDD LTE FREQUENCY BAND ALLOCATIONS

LTE Band Number	Uplink (MHz)	Downlink (MHz)	Width of Band (MHz)	Duplex Spacing (MHz)	Band Gap (MHz)
1	1920 - 1980	2110 - 2170	60	190	130
2	1850 - 1910	1930 - 1990	60	80	20
3	1710 - 1785	1805 -1880	75	95	20
4	1710 - 1755	2110 - 2155	45	400	355
5	824 - 849	869 - 894	25	45	20
6	830 - 840	875 - 885	10	35	25
7	2500 - 2570	2620 - 2690	70	120	50
8	880 - 915	925 - 960	35	45	10
9	1749.9 - 1784.9	1844.9 - 1879.9	35	95	60
10	1710 - 1770	2110 - 2170	60	400	340
11	1427.9 - 1452.9	1475.9 - 1500.9	20	48	28
12	698 - 716	728 - 746	18	30	12
13	777 - 787	746 - 756	10	-31	41
14	788 - 798	758 - 768	10	-30	40
15	1900 - 1920	2600 - 2620	20	700	680
16	2010 - 2025	2585 - 2600	15	575	560
17	704 - 716	734 - 746	12	30	18
18	815 - 830	860 - 875	15	45	30
19	830 - 845	875 - 890	15	45	30
20	832 - 862	791 - 821	30	-41	71
21	1447.9 - 1462.9	1495.5 - 1510.9	15	48	33

LTE Band Number	Uplink (MHz)	Downlink (MHz)	Width of Band (MHz)	Duplex Spacing (MHz)	Band Gap (MHz)
22	3410 - 3500	3510 - 3600	90	100	10
23	2000 - 2020	2180 - 2200	20	180	160
24	1625.5 - 1660.5	1525 - 1559	34	-101.5	135.5
25	1850 - 1915	1930 - 1995	65	80	15