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October 25, 2017

SUBMITTED ELECTRONICALLY VIA ECFS

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, NW
Washington, DC 20554

Re: **Written *Ex Parte* Presentation**

GN Docket No. 14-177, *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*

Dear Ms. Dortch:

In the above-referenced proceeding, the Commission is considering the future use of several spectrum bands above 24 GHz. In its *Report and Order*, the Commission made spectrum in, among others, the 28 GHz and 37/39 GHz bands available for mobile broadband, and in the *Further Notice of Proposed Rulemaking*, the Commission is considering additional spectrum bands for that designation.[1/] T-Mobile applauds the Commission's actions to date, which will help keep the United States at the forefront of the development of these millimeter wave bands for Fifth Generation ("5G") technologies.

Unfortunately, representatives of the satellite industry do not see this proceeding the same way. Instead of having the Commission maximize the utility of the millimeter wave bands for mobile broadband, they seek to preserve and expand access to the spectrum for satellite use in ways that will negatively impact terrestrial use of the spectrum. In the context of the *Report and Order*, they have sought reconsideration of the rules, requesting additional opportunities to locate satellite stations and to increase power flux density limits, both of which will limit mobile broadband use of the spectrum.[2/] In response to the *Further Notice of Proposed Rulemaking*,

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1/ *See Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, et al.*, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014 (2016) (subparts referred to respectively as the "*Report and Order*" and the "*Further Notice of Proposed Rulemaking*").

2/ *See* Petition for Reconsideration of SES Americom, Inc. and O3b Limited, GN Docket No. 14-177 *et al.* (filed Dec. 14, 2016) (requesting increased satellite access to the 28 GHz band); Petition for Reconsideration of the Satellite Industry Association, GN Docket No. 14-177 *et al.* (filed Dec. 14, 2016) (requesting increased satellite access to the 28 GHz and 39 GHz bands, including co-primary status with regard to UMFUS in the 28 GHz band); Joint Petition for Reconsideration of EchoStar Satellite Operating Corporation, Hughes Network Systems, LLC, and Inmarsat, Inc., GN Docket No. 14-177 *et al.* (filed Dec.

they seek access to additional spectrum and to limit use of the proposed bands and other bands for mobile broadband.[3/]

And unlike terrestrial providers of broadband services, they object to participating in auctions to secure spectrum rights.[4/] But dedicating spectrum for only one type of mobile broadband – satellite mobile broadband – is poor spectrum management. The attached study prepared by the Commission's former Deputy Chief Economist (now Director of the Public Policy Program at Stanford University and a Senior Fellow at the Stanford Institute for Economic Policy Research) Gregory L. Rosston and Stanford Professor Andrzej Skrzypacz demonstrates this point.

Rosston and Skrzypacz show that the public interest supports using auctions to issue flexible use licenses – licenses that allow licensees to choose their service and technology, including satellite operations. Auction winners can use the spectrum they are awarded for satellite service, terrestrial service, or both depending on consumer demand and business needs. Allowing auction winners to decide how they will use spectrum will relieve the Commission of the task of choosing the business plans that are best for consumers. Instead, market forces can best dictate how a licensee uses its spectrum.

In addition, Rosston and Skrzypacz reach the following conclusions relevant to this proceeding:

- There is no market failure that requires the Commission to set aside additional spectrum for satellite operations. To the contrary, many of the needs that are being met, or can be met by satellite communications, can be better satisfied by other communications systems, including incumbent satellite operations. Moreover, setting aside more spectrum for satellite use must be weighed against the opportunity cost of making the spectrum available for other services, including terrestrial use. Dedicating satellite

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14, 2016) (requesting increased satellite access to the 28 GHz and 39 GHz bands); Petition for Reconsideration of The Boeing Company, GN Docket No. 14-177 *et al.* (filed Dec. 14, 2016) (requesting increased satellite access to the 28 GHz and 39 GHz bands and an FSS allocation at 42-42.5 GHz); Petition for Partial Reconsideration of ViaSat Inc., GN Docket No. 14-177 *et al.* (filed Dec. 14, 2016) (requesting an FSS allocation at 42-42.5 GHz).

3/ *See, e.g.*, Comments of The Boeing Company, GN Dkt. No. 14-177, *et al*. (filed Sept. 30, 2016) (asking the Commission to refrain from making any identification for UMFUS in the 47 and 50 GHz bands, grant satellite systems primary access to the 40.0-42.0 GHz band, and grant shared opportunistic access to the 37/39 GHz and the 42 GHz bands); Comments of ViaSat, Inc., GN Dkt. No. 14-177, *et al*., at 5 (filed Sept. 30, 2016) (requesting primary use in the 48.2-50.2 GHz uplink band, shared use of the 47.2-48.2 GHz band, primary access in the 50.4-52.4 GHz band, an FSS allocation in the 42.0-42.5 GHz downlink band, and opportunities for satellite services in the 70 GHz/80 GHz bands and higher frequencies); Comments of Global VSAT Forum, GN Dkt. No. 14-177, *et al*. (filed Sept. 30, 2016) (advocating for shared use in the 37/39 GHz and 50 GHz bands and primary access to the 47 GHz band); Comments of the Satellite Industry Association, GN Dkt. No. 14-177, *et al*. (filed Oct. 3, 2016) (requesting primary access in the 24.75-25.25 GHz band, co-primary status with UMFUS in the 47.2-48.2 GHz portion of the 47 GHz band and in all of the 50 GHz band, and use of the 37/39 GHz, 42 GHz, 70/80 GHz, and above 90 GHz bands).

4/ *See, e.g.*, The Boeing Company *ex parte*, GN Docket No. 14-177, White Paper Attachment at 16 (filed June 30, 2016).

spectrum to provide service to unserved and underserved areas is very likely an inefficient way to meet those areas' needs.

- Concerns raised by satellite industry participants regarding the use of auctions – related to so-called "exposure" problems and satellite licensees' need for limited geographic areas to site earth stations – can be addressed by appropriate auction design and market forces. Auctions best fulfill the Commission's mandate to manage the spectrum in the public interest, particularly in contrast to the problems and inefficiencies created by designating spectrum for a particular use.
- The history of allocating spectrum for satellite use demonstrates that significant spectrum blocks have been dedicated to serve relatively few customers, prompting satellite companies to do exactly what Rosston and Skrzypacz recommend in the first instance – seek authority to use their spectrum flexibly, in order to provide terrestial services.

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Pursuant to Section 1.1206(b)(2) of the Commission's rules, an electronic copy of this letter and the Rosston and Skrzypacz report are being filed for inclusion in the above-referenced docket. Please direct any questions regarding this filing to the undersigned.

Respectfully submitted,

/s/ Steve Sharkey

Steve Sharkey
Vice President, Government Affairs – Technology and Engineering Policy

Attachment

Using Auctions and Flexible-Use Licenses to Maximize the Social Benefits from Spectrum

Gregory L. Rosston[1]

Andrzej Skrzypacz[2]

September 2017

Prepared on behalf of T-Mobile USA

I. Introduction and Executive Summary

We have been asked to evaluate the ability of auctions to accommodate different business plans and technologies, satellite as well as terrestrial, to fulfill the mandate of using spectrum in the "public interest." We understand that some satellite proponents have raised objections to participating in auctions in connection with their desires to launch or expand satellite systems.[3]

To evaluate the effectiveness of auctions and flexible-use designations for spectrum allocation and assignment when parties may have different business plans, we have examined how such auctions might work and how alternative allocation and assignment mechanisms would perform.

Based on our research and experience, we find that using auctions for flexible-use spectrum licenses that allow providers to choose their service and technology is likely to provide the best long-term benefit for consumers. Flexible-use licenses enable licensees to respond dynamically to changes in consumer preferences, technology, and competition, usually without requiring government approvals. Under this allocation mechanism, licensees could provide satellite service, terrestrial service, or a combination depending on consumer demand and their business plans. In addition, by auctioning licenses with flexible use, the Federal Communications Commission ("FCC" or "Commission") need not worry about subsequent petitions to change services or technology and related claims that such changes would unjustly enrich the licensee.

Under an auction, providers with different business models can compete for the scarce spectrum resource in the same way they compete for the rest of the resources that will be used for their proposed services – radios, transmission facilities, launch vehicles, engineers, marketing and management talent, etc. As a result, the FCC does not need to decide what business plan is the best for serving consumers, but can let the market decide and change as necessary. At the same time, auctions are sufficiently flexible that the Commission can provide some weight for services

[1] Gordon Cain Senior Fellow, Stanford Institute for Economic Policy Research and Director, Public Policy program, Stanford University.

[2] Theodore J. Kreps Professor of Economics, Graduate School of Business, Professor of Economics (by courtesy), School of Humanities and Sciences, Stanford University.

[3] *See, e.g.,* The Boeing Company *Ex Parte,* GN Docket No. 14-177, White Paper Attachment at 16 (filed June 30, 2016).

(*e.g.*, broadband speeds, voice services, reliability, etc.) it would like to see delivered to consumers.

Overall, our evaluation and analysis shows:

- the FCC should consider the incremental social value of restricting spectrum to satellite uses, which may be low or even negative because of the opportunity cost of precluding other potentially more valuable uses;
- auctions generally lead to the highest value use of spectrum;
- specific issues such as exposure risk are likely to be small relative to the value of the spectrum and most can be overcome through normal market transactions; and
- auctions with flexible-use can obviate *ex post* rent-seeking by applicants trying to expand their spectrum rights to include the valuable terrestrial rights for which they have not paid.

Our report proceeds as follows: Section II examines the social value of satellite service; Section III examines how auctions can accommodate different proposed uses and business plan concerns; Section IV provides a short overview of changes in the use of spectrum initially designated for satellite use; and Section V provides conclusions.

II. Social value of having satellite service

We first examine the social value of satellite service. While there may be some unique social value from satellite service, there is no evidence of a market failure that requires correction by setting aside spectrum for satellite service to increase social surplus. In fact, the Commission could increase coverage to unserved areas at a much lower cost by continuing to pursue reverse auctions for targeted subsidies (in which satellite providers can compete).

There appear to be multiple different proposals for satellite service: some that would provide service to portable units; some that would provide fixed satellite service to end users; and some that would provide service via a limited number of gateways on the ground. Beyond technology, there are also different types of uses and users the proposed satellite services could benefit, including service for currently unserved and underserved households, increased competition for currently served customers, coverage in remote areas, and coverage for airplanes and ships. These different types of services provide different potential social value.

Satellite service may provide service to unserved or underserved areas. This service can provide both private and public benefits. The FCC should quantify such benefits to the extent possible. In addition, the Commission should evaluate its policy tools to determine the most efficient mechanism by which these benefits may be delivered. At that point, it would determine what, if any, policy actions it should take to provide service to these areas.

In considering the benefits of satellite service, the Commission should first consider the availability of terrestrial service. Nearly all U.S. households have wireline voice service and

more than 90% of U.S. households live in census tracts that have terrestrial broadband service of at least 25 Mbps (94% in tracts that have at least 10 Mbps).[4]

Wireless providers offered 4G LTE service to more than 99% of census blocks as of two years ago.[5] 5G upgrades are likely to cover well more than a majority of households in the near future. As a result, there are likely to be less than 1% of households, or about 1.1 million households, that might benefit from fixed satellite service in terms of getting access to higher quality Internet service.[6]

Next, the Commission should consider the availability of existing satellite services. Currently, satellite broadband services like HughesNet or Exede (ViaSat) are available in almost all of the U.S. (including those portions without wireline or terrestrial wireless broadband available).[7] These satellite broadband Internet services offer download speeds as fast as 25 Mbps, comparable to wireless terrestrial LTE speeds.

HughesNet is a satellite Internet service offered by Hughes Network Systems, a subsidiary of EchoStar Corporation. HughesNet is available in the continental U.S. and in Alaska to consumers and entities with a clear view of the southern sky.[8] Through its newest service – HughesNet® Gen5, launched March 2017 – HughesNet offers consumers up to 25 Mbps download and 3 Mbps upload.[9] HughesNet Gen5 serves over 100,000 homes and small

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[4] Singer *et al.* (2017) computed from FCC Form 477 data.

[5] The FCC reports that two years ago 99.6% of census blocks had 1 or more LTE providers. *See Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993 Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services*, Eighteenth Report, 30 FCC Rcd. 14515, Chart III.A.3 Estimated LTE Coverage in the U.S. by Census Block: Mosaik, July 2015 (2015). With its recent additions of 700 MHz and 600 MHz spectrum, T-Mobile expects to build its network out to nearly 99% of the U.S. population itself. Neville Ray, T-Mobile CTO reports that "B[b]y the end of the year, we expect to expand LTE coverage to 321 million people. *Proof Positive. T-Mobile Does Unlimited Better*, T-MOBILE (July 17, 2017), https://newsroom.t-mobile.com/news-and-blogs/tmobile-best-unlimited-network.htm. NTIA reported more than 2 years ago that LTE was available to 98% of the U.S. population. *FACT SHEET: Next Steps in Delivering Fast, Affordable Broadband*, THE WHITE HOUSE OFFICE OF THE PRESS SECRETARY (March 23, 2015), https://obamawhitehouse.archives.gov/the-press-office/2015/03/23/fact-sheet-next-steps-delivering-fast-affordable-broadband.

[6] Another way of looking at the number of households is to take T-Mobile's 321 million compared to the U.S. total population of 325.6 million. *See Population*, U.S. CENSUS BUREAU, https://www.census.gov/topics/population.html, (last accessed Aug. 15, 2017). Assuming other providers do not cover anyone else leaves 4.6 million people without service. With an overall average household size of 2.6 (ignoring that rural household size is likely larger than urban household size), this corresponds to a maximum of 1.76 million unserved households. *See* HOUSEHOLDS AND FAMILIES: 2010, U.S. CENSUS BUREAU, 1 (2012).

[7] Current pricing and packages available online. *See Get the New HughesNet Gen5*, HUGHESNET (last accessed Aug. 15, 217), http://internet.hughesnet.com/residential-plans-and-pricing.html;*Find Plans in Your Area*, EXEDE INTERNET, http://www.exede.com/plan-results/freedom/(last accessed Aug. 15, 2017). In addition, other providers such as Inmarsat, O3b, X2nSat, Skycasters and others may be capable of offering satellite service.

[8] HUGHESNET, http://internet.hughesnet.com/ (last accessed July 6, 2017); Press Release, *Hughes Announces HughesNet Gen5 High-Speed Satellite Internet Service*, HUGHES, (Mar. 7, 2017) https://www.hughes.com/who-we-are/resources/press-releases/hughes-announces-hughesnet-gen5-high-speed-satellite-internet.

[9] HUGHESNET, http://internet.hughesnet.com/ (last accessed July 6, 2017).

businesses; however, including subscribers to older services, wholesale subscribers, and those receiving service through third-parties with capacity arrangements, Hughes Network Systems has over one million active users in North America for satellite Internet connectivity.[10] Service is provided via Ka-band spectrum (between approximately 18 and 30 GHz).[11]

Exede Internet is a satellite Internet service provided by ViaSat. Service is available in most of the continental U.S., Alaska, and Hawaii.[12] Exede offers consumers up to 12 Mbps or 25 Mbps download.[13] Exede also offers in-flight Internet service.[14] Globally, Exede had approximately 659,000 residential subscribers at the close of its 2017 fiscal year.[15] Service is provided via Ka-band spectrum.[16] ViaSat recently launched a new geostationary satellite promising speeds of up to 100 Mbps (and possibly 200 Mbps),[17] but its CEO reportedly "believes that most of the company's subscribers will be on tiers delivering less than that."[18]

In addition to the existing and proposed geostationary systems, multiple satellite companies have filed applications or petitions relating to new or expanded NGSO Fixed Satellite Service ("FSS") systems in the Ka and V bands (approximately 18 GHz -30 GHz and 36 GHz-51.4 GHz, respectively) in recent months. Space Exploration Holdings, LLC ("SpaceX") notes that "[w]orldwide demand for broadband services and Internet connectivity continues to evolve, with escalating requirements for speed, capacity, and reliability" and that even so, "many parts of the United States and the world lack access to reliable broadband connectivity."[19] SpaceX contends that its "[s]ystem will bring new broadband capability to the U.S. and international markets by applying cutting-edge space technologies and spectrum re-use approaches and leveraging its space-based design, manufacturing, and launch experience."[20] ViaSat highlights the "ever-

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[10] *HughesNet Gen5 Surpasses 100,000 Subscribers In Just Two Months*, NY TIMES (June 5, 2017), http://markets.on.nytimes.com/research/stocks/news/press_release.asp?docTag=201706050900PR_NEWS_USPRX____PH07611&feedID=600&press_symbol=9862296; Press Release, *Hughes Becomes First Satellite Internet Provider to Surpass One Million Active Users*, https://www.hughesnet.com/why-hughesnet/news/hughes-becomes-first-satellite-internet-provider-surpass-one-million-active-users.

[11] *FAQ: How Satellite Internet Works*, http://internet.hughesnet.com/faqs/how-satellite-internet-works/ (last accessed July 6, 2017).

[12] EXEDE INTERNET, http://www.exede.com/ (last accessed July 6, 2017).

[13] *Id.*

[14] *In-Flight Wi-Fi Service for Commercial Airlines*, EXEDE INTERNET, http://www.exede.com/exede-in-the-air/ (last accessed July 6, 2017).

[15] Press Release, *ViaSat Announces Fourth Quarter and Fiscal Year 2017 Results*, VIASAT (May 23, 2017), http://investors.viasat.com/releaseDetail.cfm?ReleaseID=1027611.

[16] *From Space to You: What It Takes to Get Exede Satellite Internet in Your Home*, EXEDE INTERNET (July 3, 2014), http://www.exede.com/blog/from-space-to-you-what-it-takes-to-get-exede-satellite-internet-in-your-home/.

[17] *ViaSat 2 Launches With Big Broadband Potential*, MULTICHANNEL NEWS (June 2, 2017), http://www.multichannel.com/news/distribution/viasat-2-launches-big-broadband-potential/413196.

[18] *Id.*; *cf.* Rosston et al. (2010) (analyzing the extent to which customers value faster broadband speeds).

[19] Space Exploration Holdings, LLC, Application for Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System, IBFS File No. SAT-LOA-20161115-00118, at 9-10 (filed Nov. 15, 2016).

[20] *Id.* at 11.

growing demand"[21] for broadband services, stating that its "satellite network would allow the company to utilize spectrum resources in the Ka and V Bands more intensively" and that "the ubiquitous coverage afforded by the NGSO constellation would enable ViaSat to serve all areas of the country—including those that have been 'left behind' by terrestrial broadband providers."[22]

The value of dedicating additional spectrum to satellite service should be weighed against the opportunity cost of this use of the spectrum. Dedicating spectrum to satellite service precludes full use of the same spectrum for terrestrial use.[23] The precluded terrestrial use might allow for increased capacity, speed, innovation, or competition for orders of magnitude more Americans than would benefit from increased spectrum allocated to satellite service. For example, there might be additional services available to hundreds of millions of urban residents that would be unavailable if the spectrum were dedicated to satellite service. As discussed above, there are about 1.1 million households without 4G service in the U.S. Dedicating spectrum to satellite services aimed at these households has likely an extremely high opportunity cost because that spectrum would no longer be available on an unrestricted basis to provide terrestrial service to the other more than 100 million homes.[24] The FCC should consider this opportunity cost when deciding whether to restrict spectrum use to satellite service.

Setting aside spectrum for satellite service is also likely to be a very inefficient mechanism to provide service to unserved and underserved areas. The FCC's rural Universal Service Fund disburses billions of dollars per year to try to provide service in rural areas. Recently, the FCC has begun using reverse auctions to provide incentives for carriers to provide service in unserved areas. In these auctions, providers bid down the amount of the subsidy they require to serve an area.[25] These reverse auctions are designed so that the most efficient service provider requiring the lowest subsidy would win the auction and provide the desired service.

Satellite providers can participate in the reverse auction process and compete to provide service to consumers, although the current Commission reverse auction proposal has a penalty for latency that would make satellite service somewhat less competitive.[26] Presumably, the rationale behind the latency penalty in the auctions is that the FCC believes that consumer welfare is diminished by that fractional delay. Implicitly, the FCC is indicating that it thinks that terrestrial

[21] ViaSat, Inc., Petition for Declaratory Ruling Granting Access to the U.S. for a Non-U.S.-Licensed Nongeostationary Orbit Satellite Network, IBFS File No. SAT-PDR-20161115-00120, at 6 (filed Nov. 15, 2016).

[22] *Id.* at 3.

[23] Later we discuss the issue of subsequent transition to terrestrial use after free award of spectrum to satellite users.

[24] We have a recent market signal of the value of the spectrum in these bands for terrestrial use, and hence the opportunity cost we discuss: Verizon has agreed to acquire StraightPath and its 28 and 39 GHz licenses for $3.1 billion. *Verizon outbids AT&T for nationwide "5G" spectrum*, ARS TECHNICA (May, 11, 2017) https://arstechnica.com/information-technology/2017/05/verizon-outbids-att-for-nationwide-5g-spectrum/.

[25] *See Comment Sought on Competitive Bidding Procedures and Certain Program Requirements and the Connect America Fund Phase II Auction (Auction 903)*, Public Notice, FCC 17-101, AU Docket No. 17-182, WC Docket No. 10-90 (rel. Aug. 4, 2017).

[26] *See Connect America Fund, ETC Annual Reports and Certifications,* Report and Order and Order on Reconsideration, 32 FCC Rcd .1624 (2017).

service without latency is more highly valued than satellite service with a delay. To be consistent with the values embedded in the proposed reverse auction design, the FCC should also consider that dedicating spectrum to satellite service that has latency would be effectively dedicating it to a service that the Commission believes consumers value less highly.

Moreover, there seem to be other, more cost-effective ways of providing service to unserved and underserved households (for example, using existing frequencies and either satellite or terrestrial technologies). Cost-adjusted vouchers would be a much more efficient way to provide service and that service could be provided by satellites or terrestrially (even if the costs of bringing the latter to certain remote areas is higher), letting the customers express their preferences for services of different types (*e.g*. level of latency), without the FCC setting its thumb on the scale and choosing the technology for them.

As Chairman Pai has stressed, the FCC should do a cost-benefit analysis[27] to see if spectrum should be set aside for satellite use. Setting aside spectrum for satellite would benefit some users who have no other service and others who would benefit from the competition or differentiation of satellite service.[28] On the cost side, however, there are two major immediate costs and one longer term cost. The immediate costs are a loss of terrestrial service to those who would otherwise get additional terrestrial service and a loss of auction revenue that would be a relatively non-distorting tax.[29] The longer-term effect would be a loss of flexibility for a provider using the spectrum to innovate and transition the use of the spectrum without returning to the FCC for permission.[30]

Satellite companies have not shown that the benefits of specific allocations to satellite outweigh the costs from restricting terrestrial use, which would be necessary (but not necessarily sufficient) evidence for such an allocation to be in the public interest.

III. Auctions to determine service and technology

Since 1994, the FCC and regulators around the world have relied successfully on auctions to allocate spectrum. Auctions with flexible-use rights have several advantages over other mechanisms to allocate scarce resources. They allow market competition to establish the proper price level (as opposed to fees set by a regulator or spectrum licenses assigned by "beauty

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[27] *See* FCC Chairman Ajit Pai, The Importance of Economic Analysis at the FCC, Remarks at the Hudson Institute, Washington, D.C. (April 5, 2017), https://transition.fcc.gov/Daily_Releases/Daily_Business/2017/db0405/DOC-344248A1.pdf.

[28] We note that there may be additional satellite uses for airplanes, ships, and the military. To the extent that such services are valuable, they should increase the willingness to pay for satellite providers and increase their chance of acquiring spectrum in an auction.

[29] The Omnibus Budget Reconciliation Act of 1993 gave the FCC auction authority and Section 309(j) stated that revenue should not be the primary factor driving the use of auctions. However, the statute does not preclude consideration of revenue. Omnibus Budget Reconciliation Act of 1993, Pub. L. No. 103-66, § 6002, 107 Stat. 312 (1993).

[30] *See* Section IV below for examples of companies coming to the FCC for permission to expand their license rights subsequent to award.

contests"), and they facilitate efficient allocation of spectrum by aligning allocation with bidders' willingness to pay.

Auctions can be designed to accommodate multiple objectives.[31] For instance, auctions can be used to determine technology and use of spectrum endogenously. For example, in the 700 MHz auction (Auction 73 held in 2008) the FCC auctioned block C with open platform conditions and all blocks A, B, C and E, with aggressive buildout requirements.[32] The FCC also set high reserve prices and the auction rules provided that if the reserve prices were not met, the buildout and open platform provisions would be relaxed and the licenses would be offered again for auction.[33] Also, the FCC has auctioned licenses with different geographical sizes (for example, in Auction 73, blocks A, B and C had different geographical splits) with the goal of accommodating different business plans.

More recent auctions have been more agnostic about the technology to be used by winning bidders. The U.K. 4G auction (in 2013) allowed the bidding to determine whether some licenses in the 2.6 GHz band would be allocated to low-power users or high-power users. Similarly, the 2009 Swedish 2.6 GHz auction was also explicitly technology-neutral.[34]

Despite general acknowledgment that auctions are regulators' best tool to allocate spectrum to the highest value use, proponents of allocating satellite spectrum without auctions raise two main issues regarding technology-neutral auctions. We discuss these issues next. In our opinion, those concerns can be reduced by an appropriate auction design and alternative allocation mechanisms (for example, the FCC simply allocating the spectrum to a particular use) create much larger problems and inefficiencies.

Exposure vs. Fragmentation Problems

The first potential complication of using auctions to determine whether spectrum is used for a terrestrial or a satellite service is the so-called "exposure" problem. The exposure problem arises in an auction with multiple licenses if a bidder's value for a package of licenses is larger than the sum of valuations of each individual license in the package *and* if other bidders have different package preferences.

For example, in the recent U.S. 600 MHz auction, T-Mobile had a disproportionally higher valuation for a package of licenses that offered it large, close to nation-wide geographical

[31] Cramton *et al*. (2011) provides additional examples about promotion of competition within auction design.

[32] Block D had further requirements that were not met and thus the block was not sold in the auction, but subsequently has been used as the basis for the FirstNet system. *700 MHz Public Safety Spectrum*, FEDERAL COMMUNICATIONS COMMISSION (last accessed Aug. 8, 2017), https://www.fcc.gov/general/700-mhz-public-safety-spectrum-0.

[33] See Brusco *et al.* (2011) for more details and an alternative auction design to accommodate such objectives.

[34] As stated by the Swedish Post and Telecom Authority, "The licenses in the 2.6 GHz band are technology and service neutral and may be used for, e.g., mobile telephony or wireless broadband." *The PTS spectrum auction in the 2.6 GHz band has been concluded – total amount SEK 2.1 billions*, PTS, http://www.pts.se/en-gb/News/Press-releases/2008/The-PTS-spectrum-auction-in-the-26-GHz-band-has-been-concluded--total-amount-SEK-21-billions/ (last accessed July 1, 2017).

coverage, than its valuations for individual licenses. Such valuations are not uncommon: when a company decides to invest in a new band, it needs to achieve a minimum scale to make it economical to incorporate the new band into phones and its network. Satellite providers may place a higher valuation on a package of licenses given the large upfront sunk cost of putting a satellite (or satellites) into orbit and hence the need to be able to offer services to many potential customers to spread that sunk cost (*i.e*. the large sunk costs create increasing returns to scale). They would therefore be forced to outbid would-be terrestrial providers who do not necessarily have the same exposure problem.

The potential or even real existence of an exposure problem does not mean that auctions should be abandoned. The severity of the exposure problem and the relative value of the different potential services are important components of understanding the best solution to spectrum allocation.

First, if a satellite service provider seeking near worldwide coverage expects to generate a much greater value than the sum of the values terrestrial service providers would provide with the same spectrum, then even though the satellite provider has a preference for a large package of licenses, it can compete in all nation-by-nation auctions and assemble the required package by outbidding terrestrial domestic providers. In other words, if the worldwide satellite provider has a total value of 20 while the sum of terrestrial domestic providers' values is 15, the satellite provider would be able to win the desired spectrum at a profit. However, if the satellite provider's value is only 10, it *should* lose the auctions; the government should not simply decide against an auction and award the license to the inefficient provider.

In fact, should there be a sequence of national auctions,[35] terrestrial providers could be in a disadvantaged position against a worldwide satellite provider because of a "fragmentation problem." The fragmentation problem arises because there are worldwide economies of scale for the use of spectrum for a specific service or technology. For a terrestrial service provider to use a particular frequency, manufacturers of end-user devices and network equipment need to develop compatible hardware. For that to happen, the world market for those devices needs to be large enough. For example, if a frequency were to be used in only a few small countries, it is likely that the hardware manufacturers would delay their designs. This problem is well understood by regulators in small countries and they address it by trying to coordinate their band plans with larger economies (for example, countries in the European Union coordinate their band plans, and Canada often follows the US's lead in band plan). As a result, if the worldwide provider wins licenses in a few large countries, other smaller countries may decide against an auction. Even if they do run auctions, local terrestrial providers will have a diminished willingness to pay for the licenses, rationally expecting the hardware constraints.

[35] We recognize that Section 647 of the ORBIT Act currently bars the use of competitive bidding for the provision of international or global satellite communications services. *See* 47 U.S.C. § 765f. The prohibition was predicated on a concern that auctions of international or global satellite authorizations "could threaten the viability and availability of global and international satellite services" due to "concurrent or successive spectrum actions in numerous countries." H.R. REP. NO. 105-494, at 65 (1998). As we explain above, however, we believe that any issues arising out of global auctions for satellite spectrum are manageable. We also note that the ORBIT Act does not prohibit the auction of authorizations that could be used for domestic satellite services or a combination of satellite and terrestrial services.

In summary, auction theory and practice point out that the exposure and fragmentation problems work in opposite directions. It is *a priori* ambiguous which of these problems is stronger and hence if in a sequence of national auctions these problems would tilt the allocation towards worldwide or towards national providers.

In any case, such tilting is likely to be decisive only if the valuations of the use of the spectrum for the competing technologies are close, and in that case resulting inefficiencies are likely to be small too. In other words, if one technology is much more valuable than the other, it would still be likely to win in the auctions despite these additional complications. A much larger risk of inefficiency would occur if a government allocates spectrum without market competition and against signals from the market for spectrum.

Second, there are ways to mitigate the exposure problem within an auction:

- The FCC can auction licenses with large geographical areas, even a nation-wide license, assuring any winner of a license a minimal geographic coverage.

- The FCC could use a package auction design (for example, the Combinatorial Clock Auction that has been used in many countries already and is specifically designed to accommodate package bidding).[36]

- In a regular Simultaneous Multiple Round ("SMR") Auction with many geographical licenses (the format most commonly used by the FCC), or in a clock auction format (used in the recent forward part of the 600 MHz Incentive Auction), bidders have a considerable flexibility in strategies that afford "self-help" against the exposure problem. For most bidders, the exposure problem is connected with the worry that they may win too few licenses (or need to overpay to acquire enough individual licenses). However, typical SMR auctions start with most active bidding on a subset of the highest-value licenses, and once the bidding on those licenses settles, bidding activity moves down to lower-value licenses. In this way, if a bidder learns that it will not be able to acquire a large enough set of the highly valuable licenses, it can exit the auction without holding any (or almost any) licenses it does not want.

  For example, in the recent past, the cable companies with no existing wireless service, and hence a potentially large exposure problem, competed successfully in FCC auctions (2006 and 2017). As auction results demonstrate, the cable companies managed to employ strategies that mitigated those risks. For a detailed account of such strategies see Bulow et al (2009).

- Finally, even if bidders end up with a few licenses they regret winning after the auction (because they did not win complementary licenses), they can use the secondary market to sell them. Since the SMR/clock auctions stop prices at the point where demand equals supply, the price for any given license tends to be very close to the levels at which another bidder would be willing to acquire the license.

[36] *See* Ausubel and Baranov (2017) for a description of the Combinatorial Clock Auction.

In summary, all these arguments point out that the exposure problem is likely small and manageable in practice. While good auction design should take exposure risk into account, there is no reason to mandate a particular service and abandon auctions altogether simply because one type of service may have some exposure risk.

Small Geographic Areas

The second major issue raised by the satellite providers is that some uses, FSS in particular, require only small geographic areas for earth stations.[37] The argument then goes that in an auction for county-sized or larger licenses, an FSS operator would not be able to compete with terrestrial services that would value the entire area of the license greater than the satellite provider would value its small piece of the area. However, the satellite provider would have a higher value on the specific earth station locations (and surrounding area needed as a buffer).

Satellite providers also argue that the secondary market would be an inefficient way for them to obtain spectrum usage rights: that once the terrestrial users obtain the licenses, they would not offer efficiency-improving sharing contracts to the FSS operators to prevent FSS operators from competing with them for end users. There is no evidence either way on this claim. Such refusal to deal would require the terrestrial licensee to have sufficient market share such that its gain from precluding satellite and bearing all the cost (while its terrestrial wireless rivals would benefit from the reduction in competition, without any sacrifice) would outweigh the potential revenue it would gain from carving out a portion of its territory for earth stations. To put it in other way: if in an area there are three terrestrial license holders and the FSS operator can take a total of 300 in revenues from the terrestrial providers, then at least one of the terrestrial providers who stands to lose 100 would be better off by striking a deal with the FSS provider to split the other 200 (and if the FSS provider creates additional value beyond reshuffling existing customers, the gains from contracting would be even larger).

Additionally, potential operators of new FSS stations have several ways to overcome these hypothetical problems:

- They can contract, consistent with FCC anti-collusion rules, with potential terrestrial operators before the auction and if they do not obtain a reasonable sharing contract, they can go directly to the auction and obtain the license. Such a pre-auction agreement could make the terrestrial operator or operators better able to compete in the auction.

- The FSS operator can win the license with geographical coverage larger than it needed, and after the auction offer a sharing agreement to a terrestrial operator. As long as the total commercial value of having a shared use of the spectrum is higher than the commercial value of avoiding interference and operating only one of the technologies, such contracting would be profitable.

[37] *See* Reply Comments of EchoStar Satellite Operating Corporation, Hughes Network Systems, LLC, and Alta Wireless, Inc., GN Docket No. 14-177 *et al.*, at 15 (filed Feb. 26, 2016).

- Finally, if these solutions would be politically impossible, the FCC could set out sharing rules in advance of the auction. Such sharing mandates would have to be clear and would diminish the value of the spectrum auctioned. The greater the mandated sharing rights, the greater the impact on the auction revenue and the value of the terrestrial service to consumers.

- Alternatively, the FCC could design the auction to determine endogenously the licenses that would offer the sharing of spectrum between the terrestrial and FSS technologies. A potential design would work as follows: for each geographical license, the FCC would define the degree of potential sharing (say, a rule that specifies how many FSS stations are allowed within the territory and constraints on their locations) and then allow all bidders (satellite and terrestrial) to bid in each area for two licenses: the general license (with the FSS operations allowed) and the "FSS interference license" (which allows FSS operations in that area; a satellite company could buy such licenses to obtain the right to "interfere" with terrestrial, or the terrestrial operator could purchase it to protect its terrestrial operations from interference). Prices for each type of licenses would increase until demand equals supply. In this way, any terrestrial bidder could prevent interference by winning the "FSS interference license" for the area. In essence, market competition would determine if the value of interference is higher or lower than the value of the FSS operations. This would also allow a terrestrial and satellite provider to pair up and beat another terrestrial provider who would not want to allow any FSS sharing.

Some other arguments that have been raised against using market competition to allocate spectrum are that auctions will result in prices that are too high to make satellite service economical. This argument, rather than being a problem with auctions, favors auctions over fees set (possibly at zero) by the regulator. If the commercial value of the spectrum is low, to the point that high prices would make it uneconomical to deploy services, then prices in the auction would be low as well. In fact, auctions are the best tool to determine the alternative value of the spectrum – whether it has a higher commercial value in terrestrial or in satellite use. If the commercial value is low in both cases, prices will be low. If it is high in one use, and low in the other, the higher-value technology will be discovered in the auction.

One may worry that the commercial value is not the only dimension the FCC should optimize for. For example, there may be some additional value to having both terrestrial and satellite systems available since that could provide redundancy and hence stability of the U.S. infrastructure. Moreover, the FCC might take consumer welfare into account, which could depend on the amount of competition after the auction. [38]

[38] Another consideration the FCC may take into account in some auctions is the effects of spectrum allocation on post-auction competition in the market (*see* Cramton *et al*. 2011). Since the satellite providers already have access to spectrum and their business models are quite differentiated from the terrestrial providers, we think that this issue is not of first order importance in the current discussion of using auctions to allocate flexible-use licenses. Competitive effects are much larger among users of the same technology. Even if the Commission thinks that these effects are important, they could also be incorporated into auction design.

As discussed above, there is no evidence that new satellite services would provide substantial additional competition for most US customers given the range of existing providers. Second, since several satellite providers offer already close to nation-wide coverage, the duplication-of-infrastructure benefits seem to be small as well. Third, any such concerns could also be accommodated by appropriate auction design. As discussed above regarding the use of auctions with flexible-use licenses, if the FCC assigns additional social value (in addition to commercial value) to sharing the spectrum for terrestrial and satellite use, it could offer a price rebate to a winner in the auction if it offers such sharing. For example, suppose the FCC determines that it is willing to sacrifice $500 per person in the impacted license area to induce spectrum sharing. It can then run the auction for regular licenses and offer rebates to winners who open their licenses to a shared use.[39]

IV. "Satellite" spectrum

The FCC has dedicated spectrum exclusively for satellite service in the past despite potentially higher private and social value in combined or terrestrial service. Satellite companies have used the process to get valuable spectrum licenses for free and then have petitioned the Commission to expand their rights to include valuable terrestrial rights. While the Commission may have been right to expand the rights to increase efficiency, the Commission mistakenly provided satellite exclusivity in the first place. It is likely that the Commission would be faced with a similar *ex post* petition if it allocates spectrum for satellite use only. It should instead award flexible licenses via auction that allow winning bidders to determine whether they will use those licenses to provide terrestrial or satellite services.

The spectrum that the FCC has licensed for satellites comprises large blocks that serve relatively small numbers of customers for Internet services.[40] Not surprisingly, therefore, satellite companies have sought Commission authorization to use their spectrum terrestrially. Globalstar, DISH, and Ligado have all petitioned the Commission to grant additional terrestrial rights to spectrum that was initially granted for free to be used for satellite service. As early as 2001, LEO satellite licensees petitioned the FCC to extend their service rights.[41] In 2003, the FCC granted "ancillary terrestrial components" or ATCs.[42] "In adopting the ATC rules, the Commission

[39] This would be analogous design to what Brusco *et al.* (2011) proposed. Other designs could achieve that policy objective as well – for example, the sharing rules could be the default and the winner could be allowed to pay a fee of some amount per person living within the area of the license, to opt out.

[40] Hughes Network Systems recently passed one million active users in North America for satellite Internet connectivity. Press Release, *Hughes Becomes First Satellite Internet Provider to Surpass One Million Active Users*, https://www.hughesnet.com/why-hughesnet/news/hughes-becomes-first-satellite-internet-provider-surpass-one-million-active-users. Note that according to the press release, Hughes estimates at most 8 million satellite internet users worldwide – it claims to have shipped 4 million systems and have a 50% market share. *Id.* Globally, Exede had approximately 659,000 residential subscribers at the close of its 2017 fiscal year. Press Release, *ViaSat Announces Fourth Quarter and Fiscal Year 2017 Results*, (May 23, 2017), http://investors.viasat.com/releaseDetail.cfm?ReleaseID=1027611.

[41] *See Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Band*, Notice of Proposed Rulemaking, 16 FCC Rcd. 15532 (2001).

[42] *Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Bands; Review of the Spectrum Sharing Plan Among Non-Geostationary Satellite Orbit Mobile*

sought to achieve spectrum efficiency benefits through 'dynamic allocation' of frequency use, and determined that these benefits can only be realized by having one licensee control both the MSS and terrestrial operations in bands allocated for MSS."[43]

Subsequent to the granting of general ATC rights with the requirement of the provision of satellite service, licensees of satellite spectrum have petitioned the FCC to expand their rights further to allow the provision of terrestrial service without the satellite requirement. The Commission granted full terrestrial rights to DISH without the need to provide satellite services using its AWS-4 band spectrum.[44] In granting DISH these beneficial rights, the Commission stated, "Specifically, we remove regulatory barriers to mobile broadband use of this spectrum, and adopt service, technical, and licensing rules that will encourage innovation and investment in mobile broadband and provide certainty and a stable regulatory regime in which broadband deployment can rapidly occur."[45]

In allocating spectrum licenses (or any object), it is important to fully detail the rights upfront. If the Commission were to decide to allocate additional spectrum specifically for satellite uses, these examples show that it will likely be pressured to provide additional terrestrial rights later. The preferable approach, which best fulfills the Commission's mandate to manage the spectrum in the public interest, would be to award a flexible-use license via auction and allow the winning bidder to determine whether to provide satellite or terrestrial services or a mix. This approach would more likely lead to the licensee that maximizes social welfare while at the same time eliminating *ex post* negotiating and windfalls.

V. Conclusions

We have examined whether the Commission should decide administratively or with the use of auctions what services should be provided using the spectrum at issue in the *Spectrum Frontiers* proceeding (and in similar situations involving allocation of spectrum). While auctions are not perfect and do not solve all concerns, the Commission should be extremely reticent to forgo the valuable information provided by auctions simply because potential licensees with a lot to gain from avoiding auctions point out some potential challenges.

The initial examination in this report shows that the welfare gains from additional dedicated satellite spectrum are likely to be low. Even if this initial examination is incorrect, using auctions would not preclude the potential social gains whereas skipping auctions and mandating satellite service precludes substantial potential efficiencies and consumer welfare gains. We also show

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Satellite Service Systems in the 1.6/2.4 GHz Bands, Report and Order and Notice of Proposed Rulemaking, 18 FCC Rcd. 1962 (2003).

[43] *Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks; Amendments to Rules for the Ancillary Terrestrial Component of Mobile Satellite Service Systems*, Report and Order, 31 FCC Rcd. 13801, ¶ 4 (2016).

[44] *Service Rules for Advanced Wireless Services in the 2000-2020 MHz and 2180-2200 MHz Bands, et al*., Report and Order and Order of Proposed Modification, 27 FCC Rcd. 16102 (2012).

[45] *Id*., ¶ 1.

that auctions can be designed to account for many of the anti-auction arguments without the downsides of administrative decision making. Finally, using flexibility ensures that long-term efficient use of spectrum is more likely.

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