

The Economic Benefits of Updating Regulations That Unnecessarily Limit Non-Geostationary Satellite Orbit Systems: Part II

Harold Furchtgott-Roth¹

November 2023

Introduction and Executive Summary

In August 2023, I prepared a study explaining the potential incremental benefits of updating the ITU's nearly 25-year-old equivalent power flux-density (epfd) rules, which were provisionally adopted in 1997 and formally adopted at WRC-2000.² Updating epfd rules would allow for greater capacity of Low-Earth Orbit (LEO) satellite systems, a form of non-geostationary satellite orbit (NGSO) systems, one of the most promising recent advances in Internet access. These NGSO systems today provide valuable and cost-effective services to people around the world, particularly in remote areas and in areas where existing broadband services are inadequate or uncompetitively priced.³ My study relied in part on an engineering study, prepared by Amazon, that calculated the incremental increase in NGSO capacity with updated epfd rules. My study recommended that WRC-23 adopt a resolution to study regulatory changes to improve spectral efficiency in operations by NGSO fixed-satellite service (FSS) systems while protecting geostationary satellite orbit (GSO) networks in the same frequency bands. As the epfd rules are contained in the Radio Regulations and a World Radiocommunication Conference is the only body with the authority to revise the Radio Regulations, it is necessary for this issue to be on the agenda of WRC-27 for rule changes to be contemplated. Presumably, during that multi-year process, engineering studies in support or opposed to a rule change would be presented and reviewed.

¹ President, Furchtgott-Roth Economic Enterprises. Mr. Furchtgott-Roth is also a senior fellow at the Hudson Institute where he is the founder and director of the Center for the Economics of the Internet. Mr. Furchtgott-Roth is a former commissioner of the Federal Communications Commission. This paper has been partially underwritten by Amazon. The views expressed, as well as any errors, in this paper are entirely those of the author and should not be attributed to anyone else.

² Furchtgott-Roth, Harold, The Economic Benefits of Updating Regulations that Unnecessarily Limit Non-Geostationary Satellite Orbit Systems (August 11, 2023). (Initial Report). Available at SSRN: <https://ssrn.com/abstract=4538619> or <http://dx.doi.org/10.2139/ssrn.4538619>

³ "With their global reach and coverage, LEO constellations are expected to dramatically expand the availability of high-speed broadband Internet access with levels of service that rival fiber optic cables in terms of speed and latency, and at significantly reduced price levels compared to traditional geostationary satellites." J. Garrity and A. Husar, "Digital Connectivity and Low Earth Orbit Satellite Constellations" Asian Development Bank. Working Paper No. 76, April 2021, Executive Summary, available at [Digital Connectivity and Low Earth Orbit Satellite Constellations: Opportunities for Asia and the Pacific \(SDWP No. 76\) \(adb.org\)](https://www.adb.org/publications/digital-connectivity-and-low-earth-orbit-satellite-constellations).

In October 2023, Brattle Group, sponsored by Viasat, prepared a report to rebut my August 2023 study.⁴ I have reviewed the Brattle Group Report, and I am not persuaded that any of the economic criticisms of my August 2023 withstand scrutiny, and I am consequently not persuaded to alter any of the opinions that I presented in my August 2023 report. The Brattle Report criticisms are incorrect for several reasons including the following:

- The choice before the ITU is whether to allow for the possibility of updating epfd rules at WRC-27, not whether to abandon interference protections for geostationary satellites.
- The ITU and national spectrum regulatory authorities frequently update spectrum interference rules and should reasonably review 2000 epfd rules.
- Businesses, including Viasat, recognize that rules change and make business and investment decisions accordingly
- Sunk costs should not affect decisions to change rules.
- The Brattle Group Report provides no evidence that updating ITU epfd rules will harm either innovation or competition.
- Economists are not in a position to weigh the merits of competing engineering studies.
- A Coasian analysis would not support the claims of the Brattle Group Report.
- Updating the epfd rules would expand NGSO system capacity.
- The distributional effects of updating epfd rules are likely positive.

A. The choice before the ITU is whether to allow for the possibility of updating epfd rules at WRC-27, not whether to abandon interference protections for geostationary satellites

The Brattle Group Report misconstrues the purpose of updating epfd rules for NGSO systems. Epfd rules would be retained with different parameters, not eliminated. The Brattle Group Report states:

Stated differently, if NGSO operators were not compelled to avoid causing unacceptable interference into GSO operations, those NGSO operators would have every incentive to exploit shared spectrum to the maximum extent, even if doing so would impose costs on GSO operators and, ultimately, the general public that exceeded any potential benefit to the NGSO operators.⁵

This statement misrepresents the recommendation to update the epfd rules, which explicitly commits to continuing to protect geostationary networks from unacceptable interference. The Brattle Group Report ignores that Article 22.2, which anchors the entire epfd framework by mandating NGSOs must protect GSOs from unacceptable interference – would remain intact, even if WRC-23 were to adopt a resolution to study regulatory changes to Article 22.⁶ Article

⁴ Coleman Bazelon and Paroma Sanyal, The Brattle Group, “Unacceptable Interference: Economic Analysis Does Not Support Degrading Protections for GSO Networks,” October 27, 2023. (The Battle Group Report). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4634764

⁵ Ibid., p. 6.

⁶ The Inter-American Proposal for a WRC-23 future agenda item specifically says that “Changes to No. 22.2 are beyond the scope of the proposed new agenda item” and resolves to “ensure the protection of GSO networks as

22.2 will underpin any proposed changes to epfd limits, and it ensures NGSOs will remain “compelled” to avoid causing unacceptable interference into GSO operations. The Inter-American Proposal seeks to preserve continuity of existing and planned GSO satellite operations.⁷

As I understand the proposal, it is merely to study the possibility of updating the epfd parameters. Satellite technology has advanced substantially since 1997, when the epfd limit approach was provisionally adopted, and there is no reason to believe that the epfd parameters for unacceptable interference in 2023 or 2027 are the same as those in 1997. The choice for the ITU is not whether to abandon epfd limits, but whether to allow for the possibility of updating them.

My report supports a proposal for WRC-23 to initiate a proceeding to study improving spectral efficiency in NGSO satellite systems because improved spectral efficiency will potentially deliver significant economic and consumer benefits. The Brattle Group Report does not address the WRC process.

B. The ITU and national spectrum regulatory authorities frequently update spectrum interference rules and should reasonably review 2000 epfd rules

The ITU and national spectrum regulatory authorities make, and frequently update, spectrum interference rules. The concept of a WRC reviewing existing regulations in response to new technologies is hardly novel. The very purpose of a WRC as enshrined in Article 13 of the ITU Constitution is to “partially or, in exceptional cases, completely, revise the Radio Regulations and deal with any question of a worldwide character within its competence and related to its agenda”.⁸ WRCs play an essential role in fulfilling the purpose of the Union “to promote the extension of the benefits of the new telecommunication technologies to all the world’s inhabitants.”⁹

WRCs routinely review existing regulations and develop new ones to enable applications of technology to serve global communications needs. For example, WRC-19 adopted several provisions that potentially affected interference between different services¹⁰ to authorize the communication of earth stations in motion (ESIM) with geostationary space stations in certain

required by the ITU Radio Regulations.” Organization of American States, “InterAmerican Proposals, Agenda Item 10 – Article 22 EPFD Limits,” September 5, 2023, at pages 3 and 8. Further, No. 22.2 of Article 22 of the ITU Radio Regulations states that “Non-geostationary-satellite systems shall not cause unacceptable interference to and, unless otherwise specified in these Regulations, shall not claim protection from geostationary- satellite networks.” ITU Radio Regulations available at [Radio Regulations \(itu.int\)](https://www.itu.int/ITU-T/terrestrial/RR).

⁷ The CITEL Future Agenda Item proposal resolves: “3 to identify any other consequential changes to the Radio Regulations resulting from [potential modifications to the regulatory provisions] to ensure that continuity of operations of existing and planned GSO networks and non-GSO systems is not disrupted, in accordance with No. 22.2, through developing transitional measures as needed;” Organization of American States, “InterAmerican Proposals, Agenda Item 10 – Article 22 EPFD Limits,” September 5, 2023, at pages 7-8.

⁸ See Article 13.1 of the ITU constitution, at [ebat-18-00332 Basic Texts-E.pdf \(itu.int\)](https://www.itu.int/ITU-T/terrestrial/RR)

⁹ Ibid., Article 1.

¹⁰ World Radio Conference – 19, Agenda and Relevant Resolutions, at [ITU Document](https://www.itu.int/ITU-T/terrestrial/RR).

frequency bands in the fixed-satellite service.¹¹ That new framework struck a balance between the existing protection requirements of terrestrial services and the view that enabling GSO FSS ESIM communications would support “important and growing global communication requirements.” Several other decisions of WRC-19 examined changes in pfd limits.¹²

WRC-23 will similarly discuss and decide another ESIM framework in response to new technology applications, this time for NGSO FSS ESIM communications.¹³ WRC-23 also will decide the appropriate regulatory actions for the provision of inter-satellite links in specific frequency bands by adding an inter-satellite service allocation.¹⁴ The agenda of WRC-23 alone demonstrates that the purpose of a WRC to review existing regulations in response to new technologies.¹⁵ Multiple proposals submitted for the future agenda of WRC-27 also seek to review existing regulations in response to new technology applications.¹⁶

WRCs commonly make decisions on regulatory procedures and spectrum allocations based on changing technologies and their evolving interference protection objectives. For example, the past five WRCs have discussed or adopted provisions related to changing interference conditions and protection requirements for unwanted emissions levels in order to protect passive systems from interference caused by the operation of other radiocommunication services.¹⁷

In each instance, WRC rules are not updated irrationally but after a careful process and findings that the benefits of rule changes outweighed the costs.

The review of epfd limits in Article 22 of the Radio Regulations falls within the above examples. NGSO systems, like the ones that are being designed and launched today, are a new technology relative to the types of NGSO systems studied in the time period before WRC-2000. Separately, the protection requirements that were used to develop the epfd limits in the late 1990s are not the

¹¹ Ibid., Resolution 158, (WRC-15), Use of the frequency bands 17.7-19.7 GHz (space-to-Earth) and 27.5-29.5 GHz (Earth-to-space) by earth stations in motion communicating with geostationary space stations in the fixed-satellite service, (AI 1.5). p. 29.

¹² Ibid., Resolution 157, Resolution 159, Resolution 761, and Resolution 766.

¹³ World Radio Conference – 23, Agenda and Relevant Resolutions, available at [WRC-23 Booklet: Agenda and Relevant Resolutions - ITU Hub](#). (WRC-23 Agenda Item 1.16). See also, RESOLUTION 173 (WRC-19) – Use of the frequency bands 17.7-18.6 GHz, 18.8-19.3 GHz and 19.7-20.2 GHz (space-to-Earth) and 27.5-29.1 GHz and 29.5-30 GHz (Earth-to-space) by earth stations in motion communicating with non-geostationary space stations in the fixed-satellite service, AI 1.16, p. 41.

¹⁴ Ibid., RESOLUTION 773 (WRC-19) – Study of technical and operational issues and regulatory provisions for satellite-to-satellite links in the frequency bands 11.7-12.7 GHz, 18.1-18.6 GHz, 18.8-20.2 GHz and 27.5-30 GHz, AI 1.17, p. 114.

¹⁵ See, e.g., WRC-23 Agenda Item 1.5 (reviewing protections in 470-960 MHz band); Agenda Item 1.8 (reviewing existing regulations on the use of unmanned aircraft systems); Agenda Item 1.9 (reviewing aeronautical provisions based on modern technology); and Agenda Item 1.14 (considering updates to regulations based on new technology).

¹⁶ See, e.g., proposals for the protections of radio astronomy due to changes in NGSO operations; and for the review of antenna size limitations in Ku-band for NGSO systems.

¹⁷ See, e.g., the work of WRC-03, Agenda Item 1.8.2 at [\[1\] AGENDA OF THE CONFERENCE \(itu.int\)](#); WRC-07 Agenda Item 1.20 at [World Radiocommunication Conference - WRC-07 \(itu.int\)](#); WRC-12 Agenda Item 1.8 at [ITU Document](#); WRC-15 Agenda Item 1.12 at [Final Acts WRC-15, World Radiocommunication Conference \(itu.int\)](#); and WRC-19 Agenda Items 1.6 and 1.13.

same protection requirements considered for GSO protections today.¹⁸ Both of these aspects warrant re-investigation to ensure spectrum is used efficiently.

Like the ITU, national spectrum regulators often change interference protections for incumbent licensees to accommodate new technologies, revised spectrum allocations, new license assignments, and spectrum license auctions. If all spectrum interference rules proposed in 1997 remained static today, spectrum-dependent services for satellite and terrestrial services would be substantially different, and less efficient, than those actually available today; the gap between technology and rules would widen.

The Brattle Group Report correctly states that clear rules are important for spectrum and property rights, and it claims that current epfd rules, developed in 1997, are still efficient.¹⁹ Clear rules are important for spectrum and for property rights, but there are few if any reasonable expectations that regulations, including spectrum interference protections, are immutable much less unreviewable. The ITU has every reason to review the epfd rules, given substantial advances in satellite technology.

C. Businesses, including Viasat, recognize that rules may change and make business and investment decisions accordingly

The Brattle Group Report states that clear rules are important for spectrum and property rights, and it claims that current epfd rules are still efficient.²⁰ However, businesses recognize that rules, including spectrum interference protections, may change. In its Form 10-K released in May 2023, Viasat specifically notes the possibility of rule changes based on new technologies as a risk factor.²¹ Investors invest in businesses that in turn make business decisions, such as long-lived investments, not because regulations such as epfd rules will never change, but with full knowledge that those rules may change.

¹⁸ Viasat earlier this year made this same observation. “The US Federal Communication Commission (FCC) has acknowledged that existing EPFD limits “were not developed with the most advanced modern GSO networks in mind.”¹¹ Indeed, those limits were designed to protect decades-old GSO network designs and do not adequately protect either (i) today’s ultrahigh-throughput GSO satellites, or (ii) the sub 1-meter antennas that GSO network (and NGSO systems alike) use to meet customer demands.” Viasat, “Ensuring Innovation and Growth Opportunities in the New Space Age,” p. 10, available at [Ensuring Innovation and New Opportunities in the New Space Age \(Updated March 2023\) \(A4\).pdf \(viasat.com\)](#)

¹⁹ Brattle Group Report, pp. 5-7.

²⁰ Brattle Group Report, pp. 5-7.

²¹ “Changes in laws or regulations, including changes in the way spectrum is regulated and/or in regulations governing our products and services, changes in the way spectrum is made available to us, or is allowed to be used by others, or competing uses of spectrum or orbital locations, could, directly or indirectly, affect our operations or the operations of our distribution partners, increase the cost of providing our products and services and make our products and services less competitive. Some regulators are considering new or additional terrestrial services in the spectrum in which we operate, which may not be compatible with the way we use, or plan to use, that same spectrum. In certain instances, such changes could have a material adverse effect on our business, financial condition and results of operations.” Viasat, Inc., Form 210-K for fiscal year ended March 31, 2023, [Form 10-K for Viasat INC filed 05/22/2023](#), p. 37.

D. Sunk costs should not affect decision to change rules

The discussion of “Lack of Input Substitutability” in the Brattle Group Report is based on the finding that investments in GSOs are fixed and sunk.²² The Brattle Group Report claims that I did not account for “large sunk investments and the lack of input substitutability (at least in the short and medium-term).”²³ The Brattle Group Report appears to claim that GSO satellites are more sensitive than NGSO satellites to rule changes because of supposedly larger sunk costs.²⁴ I have seen no evidence that GSO systems have larger sunk costs than NGSO systems, but I would not find such evidence relevant in determining whether epfd rule changes would be economically efficient.

In considering investments in the future, economists generally do not consider sunk costs. As Professor William Baumol bluntly stated: “It is important to emphasize that, in an optimal investment decision, any *historical sunk costs*, such as the machine’s employment of floor space, which would otherwise go unused, are *totally irrelevant*.”²⁵ [emphasis in italics in the original] This is the standard economic interpretation including in the documents cited in the Brattle Group Report.

The Brattle Group Report discusses uncertainty and irreversibility of investment decisions with citations to an article by Professor Robert Pindyck.²⁶ Professor Pindyck focuses on uncertainty of prices, interest rates, and exchange rates, but not specifically on whether laws and regulations should be changed, much less of a rapidly changing technology whose regulations have not been updated in more than 20 years. Professor Pindyck does not suggest that laws should never be updated even as technology changes, nor does he suggest that investments in a regulated industry are made under an assumption that regulations will not change.

Laws are constantly updated to reflect changing technology, and investors reasonably recognize that laws and regulations may change. Businesses understand that risk when they make investments, particularly long-lived investments. The risks associated with long-lived, irreversible investments apply equally well to GSOs and NGSOs.

E. The Brattle Group Report provides no evidence that updating ITU epfd rules will harm either innovation or competition

The Brattle Group Report cites three studies to claim that regulatory uncertainty adversely affects innovation.²⁷ Future regulations including ITU rules are uncertain, but the review of regulations is not an increase in uncertainty, but merely a continuation of current level of uncertainty. A

²² Ibid., pp. 10-11.

²³ Brattle Group Report, p. 9.

²⁴ Brattle Group Report, p. 9-11.

²⁵ William J. Baumol, *Economic Theory and Operations Research*, Prentice Hall, Inc., Englewood Cliffs, NJ, 1977, p. 598.

²⁶ Brattle Group Report, pp. 14-16. Robert S. Pindyck, “Irreversibility, Uncertainty, and Investment,” *Journal of Economic Literature* 29 (1991): 1110-1148, <https://web.mit.edu/rpindyck/www/Papers/IrreverUncertInvestmentJEL1991.pdf> (“Irreversibility, Uncertainty, and Investment”).

²⁷ Brattle Group Report, p. 17.

paper by Nicholas Bloom examines the effect of major international events—the JFK assassination and the 9/11 terrorist attack.²⁸ The Bloom paper does not address the effects of routine regulatory changes such as the proposed updates to epfd rules. A second paper focuses on new FDA regulation of nanomedicine.²⁹ It is not obvious that the effects on pharmaceutical innovation from new FDA regulation is analogous to ITU exercise of existing regulatory authority. A third study focuses on the effects on innovation of “economic policy uncertainty,”³⁰ in which changes in economic policies are based on an economic policy index.³¹ This index does not appear to include specific changes in spectrum regulation. None of the papers cited by the Brattle Group Report provides any evidence that updating epfd rules would harm innovation, including GSO innovation.

The Brattle Group Report has a section claiming that updating ITU epfd rules would harm competition, but the discussion is entirely about harm to GSO systems,³² not to market structure or competition. As noted above, changes in regulation affecting spectrum are anticipated by businesses such as Viasat. The ITU rules for epfd have been revisited or updated in the past, but the Brattle Group Report provides no evidence of harm to either innovation or competition from those updates.

My initial report reviews many new innovative and competitive services provided by NGSO services.³³ The Brattle Group does not dispute these innovative and competitive services. Indeed, some of the innovative services are hybrid services that combine GSO and NGSO services.³⁴ The choice for consumers and for the ITU is not a zero-sum game of *either* NGSO services *or* GSO services. Both are available, and both would be available with updated epfd rules.

F. Economists are not in a position to weigh the merits of competing engineering studies

The Brattle Group Report attaches an engineering study prepared by Viasat that disputes and criticizes the August 2023 Amazon engineering study that I cite in my initial report.³⁵ The Brattle Report is premised on the reliability of the Viasat engineering study.³⁶ In Appendix A, I attach an engineering study prepared by Amazon to rebut the Viasat engineering study. The attached

²⁸ Nicholas Bloom, “The Impact of Uncertainty Shocks: Firm Level Estimation and a 9/11 Simulation,” The London School of Economics and Political Science: Centre for Economic Performance, March 2006, https://cep.lse.ac.uk/_new/publications/abstract.asp?index=2316

²⁹ Seokbeom Kwon, Jan Youtie, Alan Porter and Nils Newman, “How does regulatory uncertainty shape the innovation process? Evidence from the case of nanomedicine,” *The Journal of Technology Transfer* (2022), <https://doi.org/10.1007/s10961-022-09980-8>.

³⁰ Mbanyele William and Wang Fengrong, “Economic policy uncertainty and industry innovation: Cross country evidence,” *The Quarterly Review of Economics and Finance* 84(2022): 208-228, <https://doi.org/10.1016/j.qref.2022.01.012>.

³¹ Economic Policy Uncertainty Index, at [Economic Policy Uncertainty Index](#).

³² Brattle Group Report, pp. 18-19.

³³ Furchtgott-Roth Initial Report, p. 1 and Section A.

³⁴ *Ibid.*

³⁵ Nandan Patel and Jona Eneberg, Viasat Inc., “Response to Amazon ‘Draft Technical Basis’ for Diluting the Article 22 EPFD Interference Protection Criteria,” October 26, 2023.

³⁶ Brattle Group Report, p. 9.

Amazon study states that the methods in the August 2023 engineering study are the same as those used in other proceedings in which the ITU updated epfd rules.³⁷

Like the authors of the Brattle Group Report, I am an economist, not an engineer. Although I have some concerns about observations made in the Viasat engineering study, neither the Brattle Group nor I am in a position to resolve the disputes between the dueling engineering studies. Those disputes presumably would be resolved by ITU Member States in consideration of updating the epfd limits were considered at a future WRC. This is precisely the purpose of the WRC process.

Indeed, the presence of differing views of engineering outcomes would seem to be the norm rather than the exception for proposals for the ITU. Not all interested parties had the same engineering views in those proceedings. In the coming months and years, I assume that other engineering studies will be prepared, some with findings similar to those of Amazon, some with findings similar to those of Viasat. Procedurally, it makes little sense to refuse to consider these engineering studies because one or more parties claim that current rules cannot be improved.

Based on the Viasat engineering study, the Brattle Group Report states that the harms to GSO satellites are not “de minimis,” but the Brattle Group does not quantify those claimed harms.³⁸ Amazon's engineering study quantified harms to GSO systems and did so in a manner that can be replicated. Neither the Viasat engineering study nor the Brattle Group Report provides a measure of claimed harms to GSO systems. It is impossible from the Brattle Group Report to determine even approximately the cost associated with a proposed updating of epfd rules. Thus, there is no basis in the Brattle Group report to conduct a cost-benefit analysis of proposed rule changes because there is no estimate of the cost.

G. A Coasian analysis would not support the claims of the Brattle Group Report

The Coase Theorem observes, that with few or no transactions costs, in the presence of externalities such as interference, parties with property rights will negotiate an efficient allocation of those property rights to resolve interference disputes.³⁹ The Brattle Group Report suggests the potential for Coasian negotiation between GSO and NGSO operators to resolve NGSO epfd interference disputes.⁴⁰ But the Brattle Group Report does not mention that neither GSO nor NGSO satellite operators have full property rights in licenses.⁴¹ With the exception of direct broadcast satellite services, satellite licensees typically do not benefit from transferring

³⁷ Annex A as attached below, prepared by Amazon.

³⁸ Brattle Group Report, p. 9.

³⁹ Ronald Coase, “The Problem of Social Cost,” *The Journal of Law & Economics* 3(1960): 1-44, <https://www.jstor.org/stable/724810>

⁴⁰ Brattle Group Report, p. 7. See particularly fn. 21.

⁴¹ Armen A. Alchian, “Property Rights,” *The Concise Encyclopedia of Economics*, available at <http://www.econlib.org/library/Enc/PropertyRights.html>. See also other works by Alchian. There are of course property rights concepts in the use of spectrum by satellite operators, but not the full range of property rights, including the ability to benefit fully from transactions. For an analogous situation with unlicensed spectrum, see Furchtgott-Roth, Harold, *The Economic Value of Property Rights Concepts in Spectrum* (November 27, 2023). Available at SSRN: <https://ssrn.com/abstract=4644950>.

their licenses, and consequently the concept of Coasian negotiation to resolve disputes makes little sense for satellite licenses.

Moreover, even if satellite licensees had complete property rights and the ability to benefit from transferring licenses, the Coasian bargaining structure would collapse under the high transaction costs associated with the large number of satellite licensees for negotiations. There are scores of systems licensed in the epfd bands, including both GSO and NGSO, commercial and government and military. The transaction costs would be extraordinarily high for an NGSO system to negotiate epfd limits with every GSO satellite owner, including military satellites operated by governments. The Brattle Group Report does not cite an example of successful negotiation between an NGSO and all GSOs globally over epfd rules, and I am not aware of any.

The Brattle Group Report correctly suggests that a Coasian analysis may be helpful in understanding certain economic concepts,⁴² but it does not follow that the Coasian analysis applies to satellite services, nor does it follow that Coase would necessarily favor keeping epfd rules unchanged after 25 years of technological change. In fact, Coase wrote specifically about spectrum licenses and interference, and he did not seek to minimize interference. As Coase said:

It is sometimes implied that the aim of regulation in the radio industry should be to minimize interference. But this would be wrong. The aim should be to maximize output. All property rights interfere with the ability of people to use resources. What has to be insured is that the gain from interference more than offsets the harm it produces. There is no reason to suppose that the optimum situation is one in which there is no interference.⁴³

H. The distributional effects of updating epfd rules are likely positive

As I explain in my initial report, many of the benefits of updating the ITU epfd rules include: expanding LEO capacity; lowers costs and prices for LEO services; expanding unnecessarily limited opportunities for new-entrant LEO constellation networks; increasing consumer welfare for services that consumers purchase; reducing costs for businesses and public sector; increasing the quality for terrestrial services; and removing harm to marginalized communities from obsolete epfd rules.⁴⁴ The Brattle Group Report claims that the distributional effects of updating the ITU's epfd rules on consumer welfare are negative, in large part because of supposedly negative effects on GSO systems.⁴⁵ As noted above, neither the Brattle Group nor I am in a position to assess competing engineering studies on the existence or extent of harms to GSO systems. The Brattle Group Report claims that NGSO services are unaffordable for impoverished populations,⁴⁶ but GSO broadband services are equally if not more unaffordable. If GSO services were more affordable, and if GSO services had better quality of service, NGSO system

⁴² Brattle Group Report, p. 7. See particularly fn. 21.

⁴³ Ronald H. Coase, "The Federal Communications Commission," *Journal of Law and Economics*, Volume 2, (1959). Pp. 903-904. [The Federal Communications Commission on JSTOR](#).

⁴⁴ Furchtgott-Roth Report, pp. 7-11.

⁴⁵ Brattle Group Report, pp. 17-18. See also pp. 2, 4, and 12.

⁴⁶ *Ibid.*, p. 18.

services would not be having substantial numbers of new broadband customers around the world. Surprisingly, the “simple, very inexpensive, fixed terminals” touted by the Brattle Group Report are one-way, direct broadcast satellite (DBS) terminals, not two-way broadband terminals.⁴⁷ My report is primarily about two-way broadband, not about one-way DBS services. As I have discussed elsewhere, the availability of new wireless services, including based on satellite services, has helped billions of people escape subsistence poverty in the past three decades.⁴⁸ For all of these reasons, the distributional benefits of updating the epfd rules are likely positive.

I. The Brattle Group makes several other errors

The Brattle Group Report does not seriously challenge that updating epfd rules would increase NGSO capacity, but it makes several mistakes in criticizing expanded NGSO capacity in my report.⁴⁹ Without citation or evidence, the Brattle Group Report incorrectly claims that I focus “only on *gross* benefits associated with NGSO systems as opposed to *incremental* benefits that could be generated only if the EPFD limits are degraded.”⁵⁰ That statement simply is incorrect. The discussion throughout my report and in the exhibit in the executive summary and in Exhibit 1 refer to “Increase in Capacity.” These are *net* benefits, not *gross* benefits.

The Brattle Group Report also incorrectly states that my report:

- “appears to assume that NGSO systems would not realize any capacity increases in the ordinary course of business, under existing EPFD limits”⁵¹. I make no such assumptions. I assume an increase in NGSO capacity as a result of updated epfd rules.
- “ignores that many of the benefits that are claimed to be generated by increased NGSO capacity would also be provided by GSO networks—including next-generation GSO networks—without any change in the EPFD limits.”⁵² Again, I focus on expanded capacity of NGSO systems, independent of GSO improvements.
- “ignores the corresponding decrease in capacity available over other NGSO systems, terrestrial networks, and GSO networks as a result of increased interference.”⁵³ The Brattle Group Report provides no evidence that NGSO systems or terrestrial networks would have reduced capacity by updating the epfd limits. Based on the Viasat Report, the Brattle Group Report does claim that GSO networks would be harmed by updating the epfd rules; the Amazon engineering study reaches a different conclusion. This is a dispute between the engineering studies, not a topic that economists can evaluate independently.

⁴⁷ Ibid.

⁴⁸ Furchtgott-Roth, Harold, Innovation As an Explanation for the Decline in the World’s Population Living at or below a Subsistence Level (October 24, 2023). Available at SSRN: <https://ssrn.com/abstract=4606078> or <http://dx.doi.org/10.2139/ssrn.4606078>

⁴⁹ The Brattle Group Report criticizes my use of a range of increased capacity rather than “empirical analysis.” But empirical evidence for raising epfd limits for NGSO satellites is not available as the epfd limits have never been lifted. See Brattle Group Report, pp. 12-13.

⁵⁰ Ibid., p. 12.

⁵¹ Ibid., p. 13.

⁵² Ibid., p. 13.

⁵³ Ibid., p. 13.

- “fails to account for any cost increase (and associated price increase) that would likely result on the GSO side due to degraded EPFD limits (e.g., due to increased interference).”⁵⁴ Whether there are any cost increases from updating epfd rules is a dispute between the engineering studies. The Brattle Group claims that there are such costs but fails to quantify, even approximately, those costs.
- “overstates potential benefits to the ‘unserved’ populations.”⁵⁵ As I discuss in Section H above, this criticism by the Brattle Group Report is incorrect. Even with GSO and NGSO satellites in 2023, approximately 2 billion people still have no access to the Internet; the Brattle Group does not dispute this figure. Stated differently, current GSO capacity, NGSO capacity, and pricing levels do not yield Internet access for 2 billion people. Many GSO satellite services, such as one-way DBS services cited by the Brattle Group Report, are not focused on providing broadband access. Updating epfd rules would lead to more capacity for NGSO systems which have more focus on broadband access. As I stated: “The greatest benefit would likely accrue to many of the 2 billion people who are not connected to the Internet.”⁵⁶ The Brattle Group Report states: “[T]hose consumers that are newly served with NGSO service are likely to also have access to GSO service (provided the existing EPFD limits and the protections they provide are not degraded).”⁵⁷ Those 2 billion people do not have access to the internet through GSO service today. As I explained in my initial report, expanded broadband-focused NGSO satellite services under updated epfd rules would provide greater opportunities for internet access, either as stand-alone systems or as hybrid systems in combination with GSO satellite services.

⁵⁴ Ibid., p. 13.

⁵⁵ Ibid., p. 13.

⁵⁶ Furchtgott-Roth Report, p. 2.

⁵⁷ Brattle Group Report, p. 13.



Annex A

David Kaufman, Alex Epshteyn, and Philippe Secher

The engineering analysis conducted to support the economic analysis “The Economic Benefits of Updating Regulations that Unnecessarily Limit Non-Geostationary Satellite Orbit System”, published in August 2023, provides a comparative analysis of a generic NGSO network intended to provide global broadband services.⁵⁸ It compares the performance of this generic NGSO network under two scenarios: with the NGSO network operating under the current epfd limits, and with the NGSO network operating under a different set of limits while still protecting GSO systems from unacceptable interference. The second scenario fully considers GSO interference protection criteria specified in ITU-R Recommendations. The analysis included both static and statistical modelling, capturing both the typical interference scenario between the NGSO network and GSO systems and a second-by-second assessment over a 24-hour period. When the NGSO network is compared to a scenario where the EPFD limits are updated, taking into account GSO protection criteria, it is found that capacity of the generic NGSO network can be improved by 181% and the number of satellites in the generic NGSO network can be reduced by 28%.

This type of comparative analysis has already been undertaken by the ITU-R in published reports and these reports arrived at the same conclusions, namely improving and modernizing EPFD limits will improve the performance of NGSO systems without harming GSO operations. For example, under WRC-19 agenda Item 1.6, extensive study was undertaken to evaluate the manner in which epfd limits were developed during the 2000 time period. Although the focus of that agenda item at the time was on the Q/V band, Report ITU-R **S.2462**⁵⁹ studied and concluded that for bands below 30 GHz the existing methodology used to derive the epfd limits results in spectrum inefficiencies and inaccuracies. The studies in Report ITU-R **S.2462** indicated that “*sharing methodologies between non-GSO and GSO FSS systems based on epfd limits masks as was done in frequency bands below 30 GHz are extremely system dependent*” and “*this situation can result in spectrum inefficiencies*”. It further indicated that the “*Optimal use of orbit and spectrum resources in the 50/40 GHz requires a more equitable regulatory environment between GSO networks and non-GSO FSS systems than has been established in bands below 30 GHz in order to take advantage of next generation satellite technology to provide high capacity broadband services, while utilizing benefits of both non-GSO and GSO satellite orbits*”. As this demonstrates, published ITU-R Reports and Recommendations conclusively support the approach and conclusions that were implemented in the technical assessments and used to support the economic conclusions in the study.

The bottom line is clear: the current EPFD limits significantly constrain the operation of non-GSO systems and can be improved while still providing protections to GSO networks in

⁵⁸ <https://ssrn.com/abstract=4538619>

⁵⁹ https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-S.2462-2019-PDF-E.pdf

accordance with the GSO published protection criteria in Recommendation ITU-R S. 1432⁶⁰. The benefits to the worldwide community are also clear: additional capacity to help bridge the digital divide and lower cost of services.

Viasat's response to Amazon's engineering analysis, contained in Appendix A of "***Unacceptable Interference: Economic Analysis Does Not Support Degrading Protections for GSO Networks from the Brattle Group***" ("Viasat study")⁶¹, is fundamentally flawed and does not negate the results used to derive the results and finding of economic benefits in Harold Furchtgott-Roth's original study. The following points in the Viasat study are flawed or misleading:

- The Viasat study criticizes the Amazon study for only using an I/N interference criteria taken from Recommendation ITU-R S.1432, "Apportionment of the allowable error performance degradations to fixed-satellite service (FSS) hypothetical reference digital paths arising from time invariant interference for systems operating below 30 GHz", and indicates that this is not appropriate to use for NGSO networks. This is incorrect and misleading. Recommendation ITU-R S.1432 defines the criteria for acceptable performance degradations for the FSS systems arising from interference, including both NGSO and GSO. The Recommendation clearly states that this criteria applies for all FSS systems, including non-GSO systems: "Interference from FSS systems, including non-GSO FSS systems, accounts for 25% of the clear-sky system noise."⁶²
- The Viasat study criticizes the Amazon study for using a "static" I/N protection criteria when NGSO systems do not provide constant interference. Amazon included *both* static *and* statistical analyses in its study. Consideration of a static interference criteria that represents GSO protection margins is an appropriate means to evaluate the typical interference that a GSO system may experience from an NGSO system, whereas fine-grain time-series analysis is needed to capture outlier cases which may cause short-term interference. The static computations that Amazon provided in its study are based on the 90th percentile epfd limits – i.e. they capture 90% of all interference scenarios that GSO systems may experience. If anything, this analysis is conservative and exaggerates the typical, or median, interference scenarios. This analysis clearly demonstrates that the long-term epfd limits can be improved, providing adequate protection to ensure NGSO systems do not cause unacceptable interference into GSO networks without harming GSO operations as claimed by the Viasat study.
- The Viasat study indicates that the Amazon study does not account for side-lobes or short-term interference criteria. Amazon's study considers both the typical interference that a GSO system may experience from NGSO systems and short-term interference. NGSO side-lobes primarily contribute to short-term interference, which occurs during in-line conjunctions between an NGSO satellite, a GSO satellite, and a GSO earth station, when the GSO earth station may have little antenna gain discrimination between the wanted signal and the interfering signal. Amazon's study considers short-term interference in both the background section and a section that quantifies the effect that the current epfd limits have on NGSO network coverage and the number of satellites required in an NGSO network.

⁶⁰ <https://www.itu.int/rec/R-REC-S.1432-1-200604-I/en>

⁶¹ https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4634764

⁶² See Recommendation S. 1432, pp. 4.

Notably, the Viasat study does not provide quantifiable analysis to demonstrate the impact to GSO networks of updates to epfd limits or to support the claim that adjusting the limits would cause significant impact to GSO networks. The Amazon study, by contrast, supports the argument that that the benefits of epfd limit updates to NGSO systems would greatly outweigh the negligible impact to GSO systems. The Amazon study also provided its methodology so that the analysis could be verified and replicated.