APPLICATION FOR GATEWAY EARTH STATION

I. OVERVIEW

The Commission has authorized Space Exploration Holdings, LLC ("SpaceX") to launch and operate a constellation of 4,409 non-geostationary orbit ("NGSO") satellites (call sign S2983/S3018) using Ku- and Ka-band spectrum.[1] In doing so, the Commission recognized that granting the SpaceX Authorization would "allow SpaceX to make efficient use of valuable spectrum resources more safely, quickly, and cost-effectively as it initiates a new generation of broadband services available to customers worldwide, including those in areas previously underserved or even totally unserved by other broadband solutions."[2] In May 2019, SpaceX began launching satellites to populate its constellation.

This application, filed by a sister company, SpaceX Services, Inc. ("SpaceX Services"), seeks authority to operate a Ka-band gateway earth station that SpaceX will use to deliver broadband data between the satellites of its NGSO system and terrestrial Internet exchange points. Specifically, SpaceX Services seeks authority for eight technically identical 1.5-meter antennas in Hawthorne, California (the "Hawthorne Gateway"). Consistent with SpaceX's space station authorization, these earth stations will transmit in the 28.6-29.1 GHz and 29.5-30.0 GHz bands and receive in the 17.8-18.6 GHz and 18.8-19.3 GHz bands.

Below, we discuss certain spectrum sharing issues relevant to the operation of these earth stations. We then demonstrate that grant of this application would serve the public interest. Lastly,

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[1] *See Space Exploration Holdings, LLC*, 33 FCC Rcd. 3391 (2018) ("SpaceX Authorization"); *Space Exploration Holdings, LLC*, 34 FCC Rcd. 2526 (IB 2019) ("SpaceX Modification"). These authorizations anticipate that Kaband spectrum would be used for gateway communications.

[2] SpaceX Modification, ¶ 1.

we provide technical information to supplement the information provided on Form 312. To support its ambitious timetable for launching satellites and deploying broadband services, SpaceX Services requests that the Commission grant the requested license as expeditiously as possible.

II. SPECTRUM SHARING ISSUES

Under the Commission's spectrum allocations and the plan adopted for the Ka-band in particular,[3] SpaceX Services will need to share with a variety of other systems operating in its bands. Below we demonstrate that the proposed Hawthorne Gateway will comply with all relevant sharing requirements.

A. Uplink Bands

FSS is primary throughout the 28.35-29.1 GHz band, with NGSO designated as secondary to GSO in the 28.35-28.6 GHz portion and NGSO designated as primary in the 28.6-29.1 GHz portion. FSS is co-primary with Mobile Satellite Service ("MSS") in the 29.5-30.0 GHz band, with NGSO designated as secondary to GSO.[4]

The Comsearch Report submitted with this application confirms that SpaceX Services has coordinated with existing terrestrial licensees in these bands in compliance with the Commission's rules and can operate without causing harmful interference to any such deployments. SpaceX Services makes no claim of interference protection from U.S.-licensed GSO FSS systems in the 29.5-30.0 GHz band. In addition, SpaceX Services will comply with the applicable equivalent power flux-density ("EPFD") limits set forth in Article 22 and Resolution 76 of the ITU Radio Regulations, which the Commission has found to be sufficient to protect GSO systems against

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[3] *See Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, 32 FCC Rcd. 7809, App. B (2017) ("*NGSO Update Order*").

[4] *See id.*

harmful interference.[5] SpaceX has demonstrated that its NGSO system will comply with these EPFD limits, and doing so is a condition of its Authorization.[6]

B. Downlink Bands

The Commission has allocated the 17.8-18.3 GHz band on a primary basis to the terrestrial fixed service ("FS") and on a secondary basis for FSS. The 18.3-18.6 GHz band is allocated on a primary basis to FSS, with NGSO secondary to GSO and subject to international EPFD limits. The 18.8-19.3 GHz band is allocated to FSS on a primary basis, with NGSO designated as primary.

SpaceX has previously demonstrated that its NGSO system will protect terrestrial fixed stations in the 17.8-18.6 GHz and 18.8-19.3 GHz bands, in compliance with a condition placed on its license.[7] Moreover, the Comsearch report submitted with this application confirms that there should be no additional limitations placed on operations of the Hawthorne Gateway. Similarly, SpaceX has demonstrated that its NGSO system will comply with the relevant EPFD limits in the 18.3-18.6 GHz band, which the Commission considers sufficient to protect GSO networks from unacceptable interference.[8]

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[5] *See, e.g., Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range*, 16 FCC Rcd. 4096, ¶ 77 (2000) (concluding that implementation of EPFD limits "will adequately protect GSO FSS networks"); 47 C.F.R. § 25.289 (NGSO satellite systems that comply with EPFD limits will be deemed not to cause unacceptable interference to any GSO network). SpaceX believes that the EPFD limits designed to protect GSO FSS systems will also protect GSO MSS systems in the band.

[6] *See* SpaceX Authorization, ¶¶ 40(b), (d), and (e); 47 C.F.R. § 25.115(f)(1) (incorporating certification requirement in 47 C.F.R. § 25.146(a)(2)).

[7] *See* SpaceX Modification, ¶ 29.

[8] *See* SpaceX Authorization, ¶ 9.

III. GRANT OF THIS APPLICATION WOULD SERVE THE PUBLIC INTEREST

Granting this application would serve the public interest by helping to speed broadband deployment throughout the United States by authorizing the ground-based component of SpaceX's satellite system. U.S. and worldwide demand for broadband services and Internet connectivity continues to increase with escalating requirements for speed, capacity, and reliability and ongoing adaptations for usage. The volume of traffic flowing over the world's networks has exploded, with one report estimating that annual global Internet protocol traffic reached 1.5 zettabytes in 2017 – meaning that approximately 1,500 billion gigabytes of data were exchanged worldwide that year.[9]

Yet, as the Commission has recognized, many communities across the United States and the world still lack access to reliable broadband connectivity, preventing them from fully participating in economic, social, and civic activities.[10] To help close this digital divide, SpaceX is designing, constructing, and deploying an innovative, cost-effective and spectrum-efficient satellite system capable of delivering robust broadband service to customers around the world. SpaceX has already secured U.S. authority for the space station components of its NGSO system. This application takes the next step by seeking authority for one of the gateway earth stations that

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[9] *See* Cisco Visual Networking Index: Forecast and Methodology, 2017-2022, at 1, CISCO (Nov. 26, 2018), https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paperc11-741490 html.

[10] *See, e.g., Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion*, 33 FCC Rcd. 1660, ¶ 50 (2018) (noting that "over 24 million Americans still lack fixed terrestrial broadband at speeds of 25 Mbps/3 Mbps," and that "the gap in rural and Tribal America remains notable: 30.7 percent of Americans in rural areas and 35.4 percent of Americans in Tribal lands lack access to fixed terrestrial 25 Mbps/3 Mbps broadband"). Internationally, the disparities between broadband access and absence are even greater, with 4.2 billion people (or 57% of the world's population) offline. *See* BROADBAND COMMISSION FOR SUSTAINABLE DEVELOPMENT, "Open Statement from the Broadband Commission for Sustainable Development to the UN High-Level Political Forum (HLPF)" (July 11, 2016), http://broadbandcommission.org/Documents/publications/HLPF-July2016.pdf. *See also* BROADBAND COMMISSION FOR SUSTAINABLE DEVELOPMENT, "The State of Broadband 2015," at 8 (Sep. 2015), http://www.broadbandcommission.org/Documents/reports/bb-annualreport2015.pdf ("A large body of evidence has now been amassed that affordable and effective broadband connectivity is a vital enabler of economic growth, social inclusion and environmental protection." (footnotes omitted)).

will connect the satellite system to the terrestrial Internet. Accordingly, an expeditious grant of this application would serve the public interest.

Respectfully submitted,

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TECHNICAL APPENDIX

In this Technical Appendix, SpaceX Services provides additional information on the proposed operations of its gateway earth station to supplement the data provided in Schedule B to Form 312 filed with this narrative application.[11]

A. Minimum Elevation Angle

SpaceX Service's gateway earth stations will communicate only with those SpaceX satellites that are visible on the horizon above a minimum elevation angle. In the very early phases of constellation deployment and as SpaceX first initiates service, this angle may be as low as 25 degrees, but this will return to 40 degrees as the constellation is deployed more fully and more satellites are in view of a given gateway site. For purposes of this application, SpaceX Services has supplied the lower angle in order to capture the full potential range of service.

B. Antenna Patterns

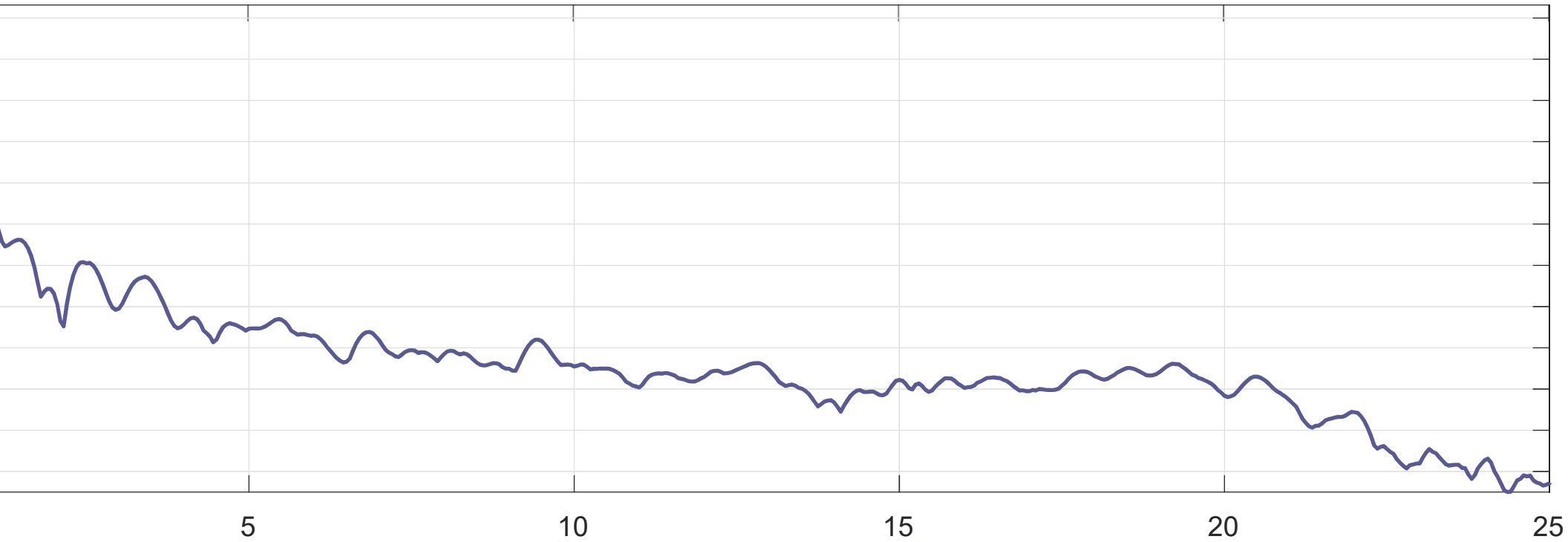
SpaceX will comply with a mask similar to the one in Section 25.209(a)(3) applicable to earth station antennas operating in the 24.75-25.25 GHz and 28.35-30.0 GHz bands with geostationary satellites but will improve that pattern to -3 dBi (rather than 0 dBi) beyond 25 degrees off-axis. The mask can be stated as follows:

$29-25\log_{10}\theta$	dBi	for $2° \leq \theta \leq 7°$.
8	dBi	for $7° < \theta \leq 9.2°$.
$32-25\log_{10}\theta$	dBi	for $9.2° < \theta \leq 25°$.
-3	dBi	for $25° < \theta \leq 180°$.

[11] To the extent relevant, SpaceX Services hereby incorporates the technical information submitted with SpaceX's space station applications. *See* IBFS File Nos. SAT-LOA-20161115-00118, SAT-LOA-20170726-00110, and SAT-MOD-20181108-00083.

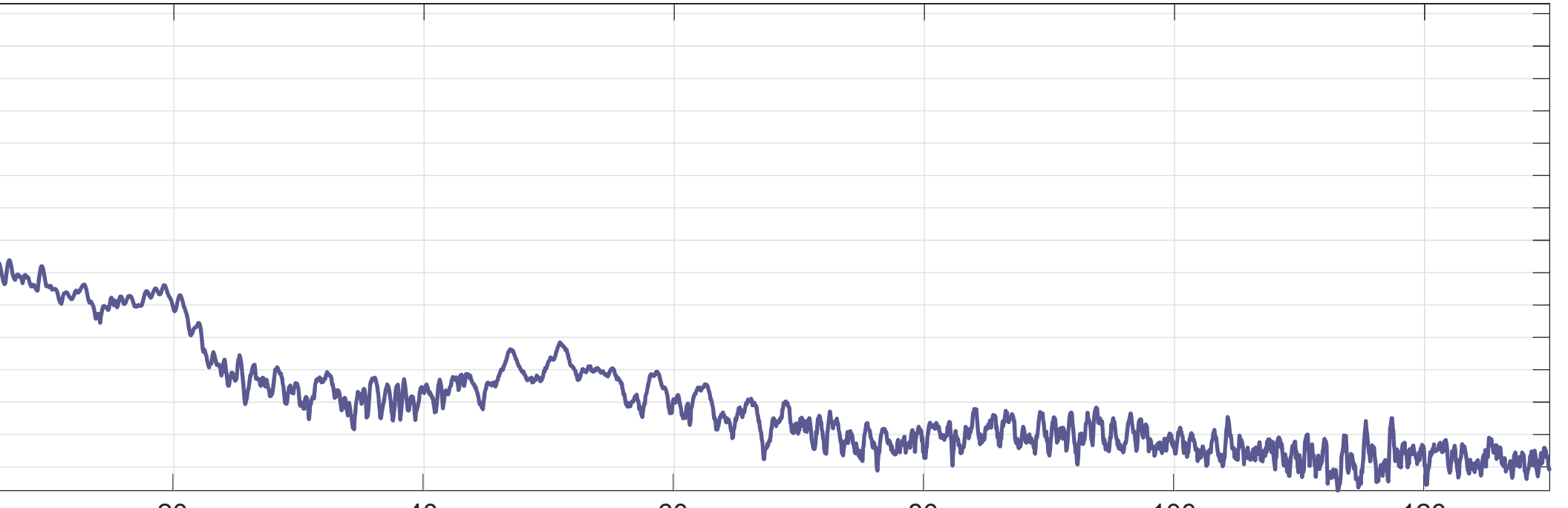
Consisten with Section 25.209(a)(3), "[t]his envelope may be exceeded by up to 3 dB in 10% of the range of θ angles from ±7-180°, and by up to 6 dB in the region of main reflector spillover energy."[12] In addition, the half power beamwidth for the proposed antenna is 0.5 degrees at 30 GHz.

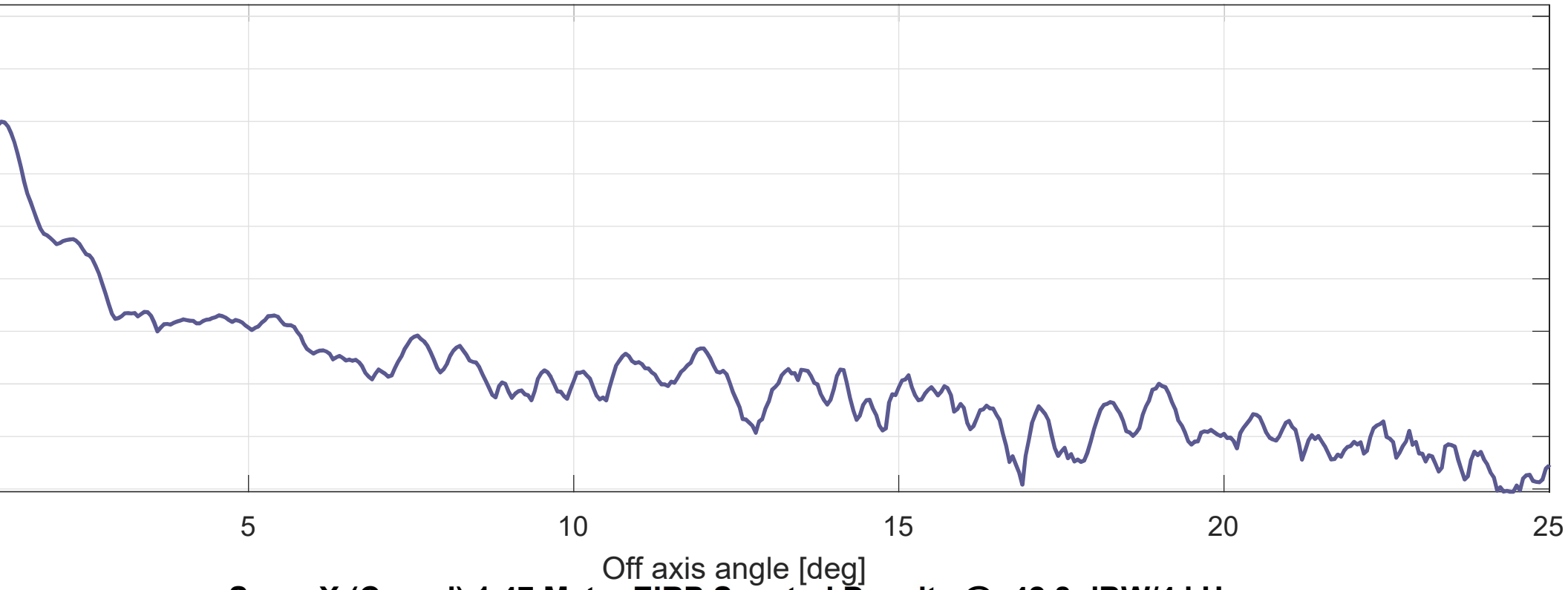
[12] *Id.* § 25.209(a)(3).



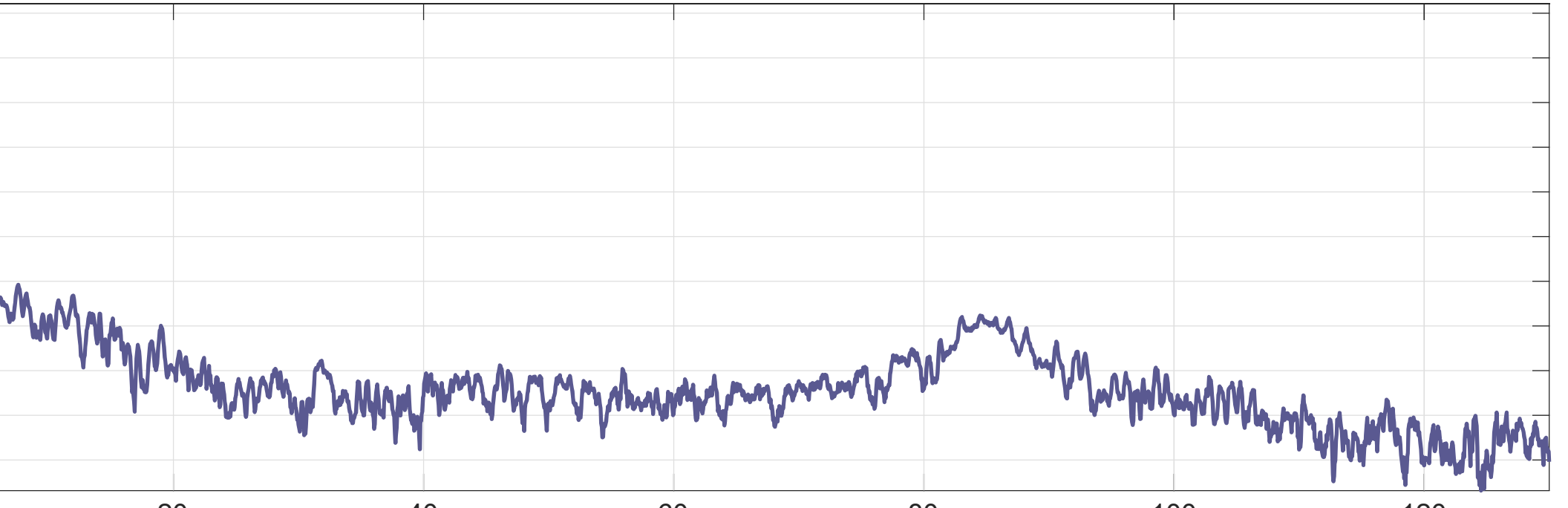
SpaceX (Co-pol) 1.47 Meter EIRP Spectral Density @ -42.8 dBW/4 kHz input per polarization

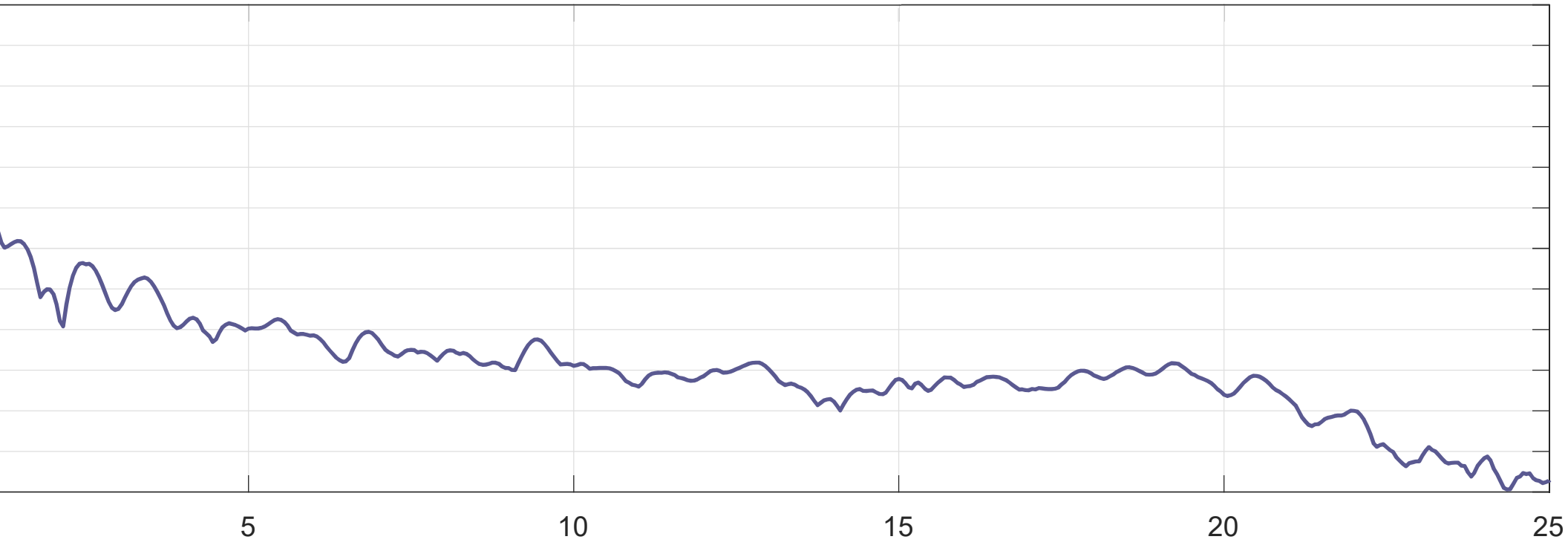
Off axis angle [deg]





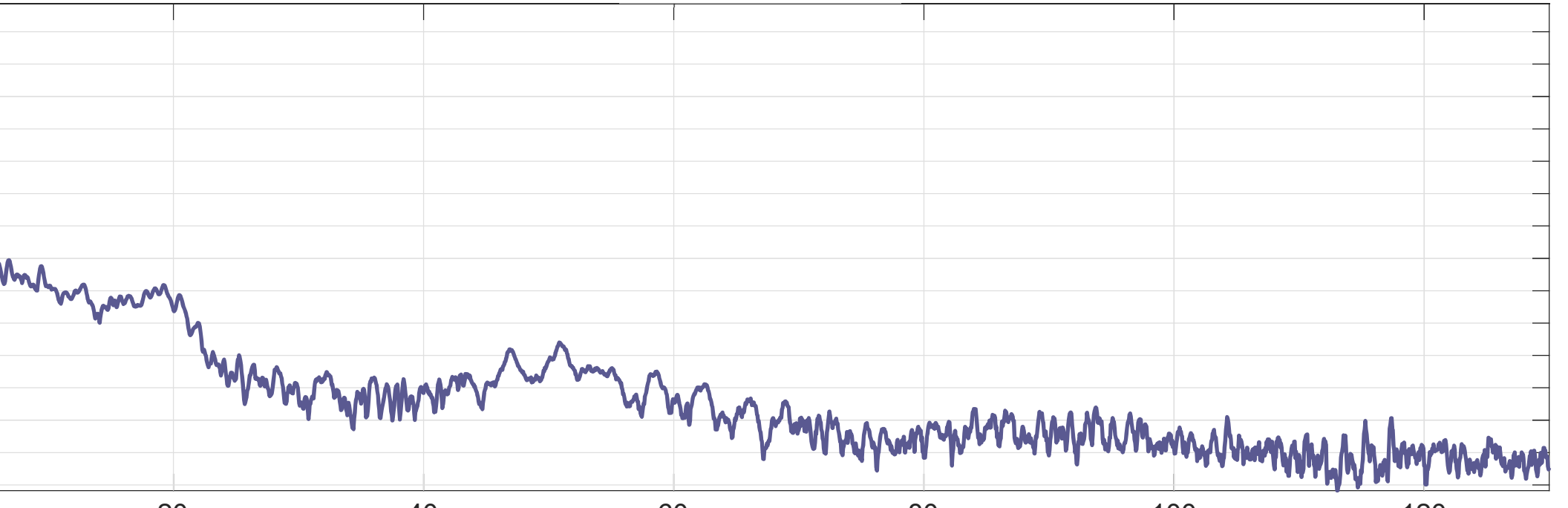
SpaceX (Co-pol) 1.47 Meter EIRP Spectral Density @ -42.8 dBW/4 kHz input per polarization SpaceX (Cross-pol) 1.47 Meter EIRP Spectral Density @ -42.8 dBW/4 kHz input per polarization

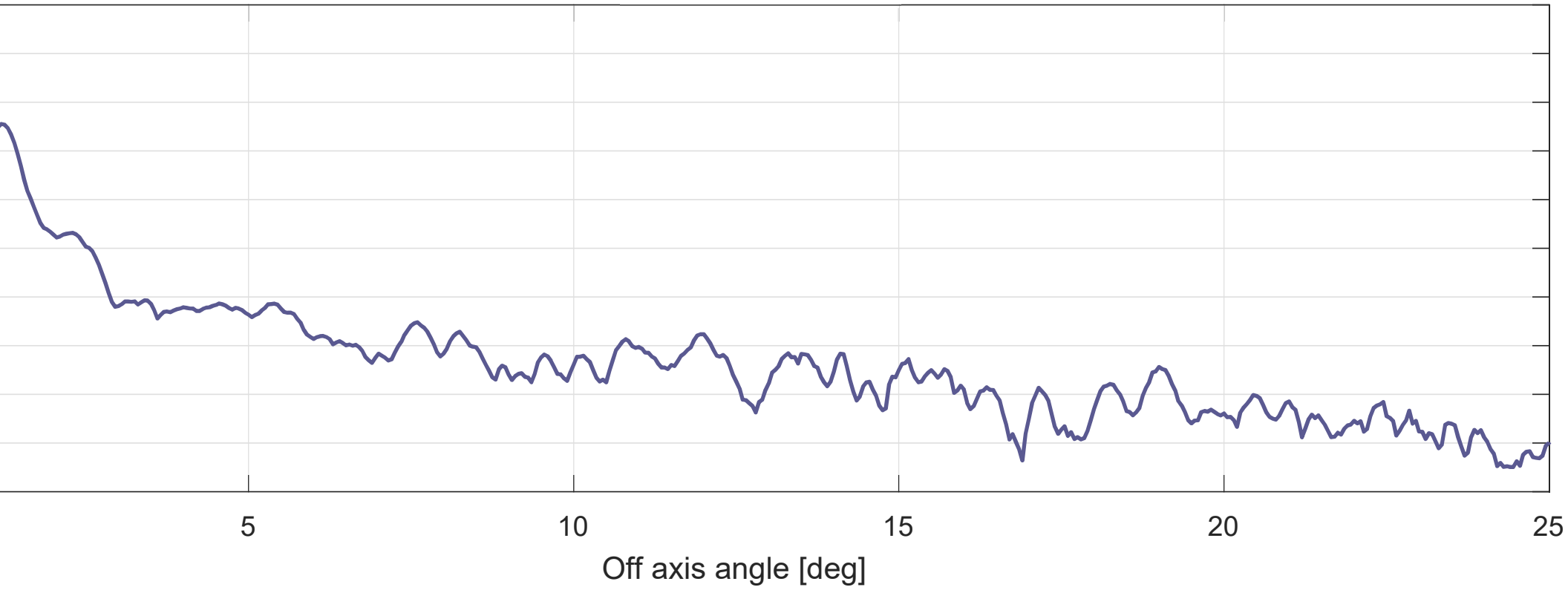




SpaceX (Cross-pol) 1.47 Meter EIRP Spectral Density @ -42.8 dBW/4 kHz

SpaceX (Co-pol)
1.47 Meter Gain





SpaceX (Cross-pol)
1.47 Meter Gain