TECHNICAL APPENDIX

Application for Modification

TABLE OF CONTENTS

TECHNICAL APPENDIX

I. INTRODUCTION

Amazon holds authority from the Federal Communications Commission ("FCC" or "Commission") to launch and operate a constellation of 3,236 low earth orbit ("LEO") satellites across three orbital shells (the "Kuiper System").[1] Amazon received this authority as a part of the 2020 Ka-band processing round.[2] Since the original grant, as part of its efforts to continually improve the Kuiper System, Amazon has optimized the orbital parameters of its constellation to increase system efficiency without having any material impact on the interference environment. The proposed modification would allow Amazon to deploy the Kuiper System consistent with this optimization, which would position Amazon to better serve its customers by enabling seamless coverage during early deployment phases with fewer satellites.

This Technical Appendix provides a detailed description of the proposed system modification to the relative orbital positions of the authorized Kuiper System satellites.[3] In addition, it demonstrates that the proposed change to the constellation's orbital parameters does

---

[1] *See* Kuiper Systems LLC, Application for Authority to Deploy and Operate a Ka-band Non-Geostationary Satellite Orbit System, Order and Authorization, 35 FCC Rcd 8324 (2020) ("*Kuiper System Authorization*"); Kuiper Systems LLC, Request for Modification of the Authorization for the Kuiper Systems LLC NGSO Satellite System, Order and Authorization, SAT-MOD-20211207-00186, DA 23-114 (rel. Feb. 8, 2023) ("*Modification Order*").

[2] *See Kuiper System Authorization*; Application of Kuiper Systems LLC for Authority to Launch and Operate a Non-Geostationary Satellite Orbit System in Ka-band Frequencies, IBFS File No. SAT-LOA-20190704-00057 (filed July 4, 2019) ("Original Application").

[3] As noted in the narrative accompanying the Modification Application, to the extent not otherwise indicated or reflected in this application or Amazon's pending modifications, as supplemented, Amazon certifies that the information previously provided to the Commission in Amazon's most recent modification, *see* Application for Modification of Kuiper Systems LLC, IBFS File No. SAT-MOD-20211207-00186 (filed Dec. 7, 2021) ("Orbital Debris Modification Application"), is unchanged and incorporated by reference. *See* 47 C.F.R. § 25.117(c).

not impact the Kuiper satellites' spectrum sharing capabilities and that the Kuiper System, as modified, satisfies the relevant orbital debris mitigation requirements. Annex A addresses spectrum sharing with non-geostationary satellite orbit ("NGSO") fixed-service satellite ("FSS") operations in the 2020 Processing Round. Separately, the Schedule S attachment provides modified orbital information. Amazon has supplemented the Schedule S with an additional spreadsheet document that includes the full orbital parameters for all modified orbits.

II. ORBITAL RECONFIGURATION

The proposed modification primarily reconfigures two orbital elements: (1) the right ascension of the ascending node ("RAAN"); and (2) the mean anomaly ("MA") of each satellite. The proposed modification will also alter the inclination of two satellites by three degrees and reduce the total number of satellites in the constellation. These changes will enable the Kuiper System to provide improved service to users without altering the altitude of any satellite. The proposed modification will continue to use three orbital shells at altitudes of 590 km, 610 km, and 630 km, as authorized by the Commission. The Schedule S attachment provides detail on the modified orbital parameters, which are summarized in Table 1, below.

Table 1: Summary of Updated Orbital Parameters of the Original and Modified Kuiper System

Orbital Shell		Original Kuiper System			Modified Kuiper System		
Altitude (km)	Inclination (deg)	Orbital Planes	Satellites per Plane	Total Satellites	Orbital Planes	Satellites per Plane	Total Satellites
630	51.9	34	34	1156	289	4	1156
610	42	36	36	1296	1292	1	1292
590	33	28	28	784	782	1	782
590	30	0	0	0	1	2	2
Total				3236			3232

Figure 1 below compares the RAAN and MA of the original Kuiper System and the Kuiper System as modified by this application (the "Modified Kuiper System") using the 590 km, 33 degree inclination shell as an example.

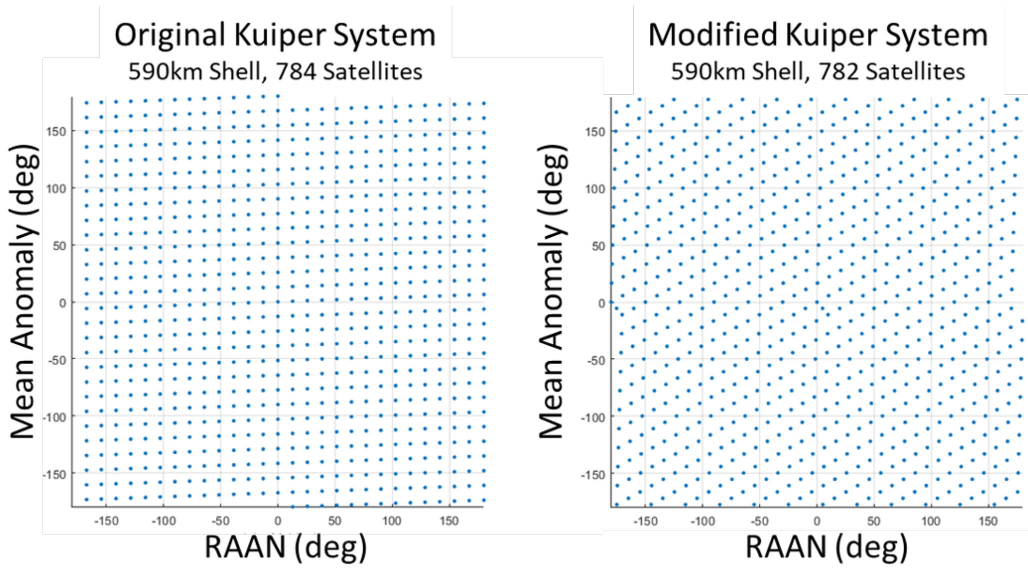


Figure 1: Comparison of the Original vs Modified 590 km/33 Degree Orbital Shell

Here, both plots show a lattice view depicting the relative RAAN and MA of each satellite in the 590 km orbital shell. In the Kuiper System, this shell consists of 28 planes each with 28 satellites depicted as 28 vertical lines each consisting of 28 points, whereas, in the Modified Kuiper System, this shell has 782 planes each with one satellite. In sum, the proposed modification places each satellite in its own plane, adjusts the MA of each satellite, and decreases the number of satellites.

The planned service area is still between 56 degrees north and south of the equator. The minimum elevation angle remains at 35 degrees for user links and 20 degrees for gateway "(GW") links. The Modified Kuiper System relies on the same frequency band plan as the original Kuiper

System. The Kuiper System's power flux-density ("PFD") and beam footprint size on the ground also remain unaltered.

III. INTERFERENCE PROTECTION AND SPECTRUM SHARING

The spectrum utilized by the Kuiper System is shared with terrestrial fixed service ("FS"), geostationary satellite orbit ("GSO") systems, and NGSO systems. Amazon has conducted analysis for each of these cases to assess the impact of the modification and determined that there will be no material increase in interference levels compared to the original Kuiper System.

A. Interference Protection for FS Systems

The Kuiper System is designed to co-exist with terrestrial FS operations. Amazon previously demonstrated compliance with the provisions of Sections 25.208 and 25.146(a)(1) and the limits set forth in Article 21 of the ITU Radio Regulations in the prior filing approved by the Commission (the "Original Application").[4] The Modified Kuiper System will maintain full compliance with those same provisions. Because the Modified Kuiper System does not change the altitudes or RF characteristics of any satellites, the PFD produced by each satellite over all scan angles will remain the same as provided in the Original Application. And, because these PFD limits establish permissible interference into FS systems, the Modified Kuiper System will not increase interference into FS systems.

B. Interference Protection for GSO Systems

Amazon has shown that the Kuiper System will comply with all Equivalent Power Flux-Density ("EPFD") limits as required by Section 25.146 of the Commission's rules and set forth in

[4] *See* Original Application, Technical Appendix at Annex A. Amazon's grant of the Original Application also requires compliance with these limits. *See Kuiper System Authorization*, ¶ 59(e).

Article 22 of the ITU Radio Regulations.[5] The proposed modification will reduce the total number of satellites in the constellation and will not affect any of the major variables which impact EPFD results. Therefore, the Modified Kuiper System will comply with EPFD limits and protect GSO systems consistent with the authorization for the Kuiper System.

Amazon hereby certifies as part of this application that it will comply with applicable[6] EPFD levels in Article 22, Section II and Resolution 76 of the ITU Radio Regulations.

C. Interference with Respect to Other NGSO Systems

The proposed modification will have no material effect on the interference environment of other NGSO systems in the 2020 Processing Round.[7] The key design parameters that impact interference into other NGSO systems are unaffected by the proposed modification. Specifically, the proposed modification does not

- adjust the orbital altitude of any satellite in the constellation;
- change the maximum PFD on the ground produced by Kuiper System satellites;
- impact the maximum EIRP density produced by Kuiper System Customer Terminals ("CTs") and gateways ("GWs");
- change the minimum elevation angle used to define serviceable regions for each satellite to CTs and GWs (35-degree minimum elevation angle for CT, 20-degree minimum elevation angle for GW); or

[5] *See* Original Application, Technical Appendix at Annex B.

[6] Regulations apply to 27.5 – 29.1 GHz and 29.5 – 30 GHz uplink bands and 17.8 – 18.6 GHz, 18.8 – 19.3 GHz, and 19.7 – 20.2 GHz downlink bands.

[7] Additionally, Amazon is required to protect NGSO systems licensed in the 2016/2017 processing round. *See Modification Order* ¶ 31.

- change the number of simultaneous satellites transmitting or receiving co-frequency beams to a single ground location (Nco) (Nco = 1 for CT beams, and Nco = 4 for GW beams).

Because the proposed modification does not alter the key parameters affecting interference into other NGSO systems, and instead *reduces* the number of Kuiper System satellites, the Modified Kuiper System will not increase interference to other NGSO systems.

To verify this, Amazon performed a large number of simulations that demonstrate that the Modified Kuiper System will not increase interference into other NGSO systems in the 2020 Processing Round. These simulations compute the interference-to-noise ("I/N") ratios over long periods of time to obtain meaningful statistics. The resulting plots provided in Annex A show that the I/N statistics showing the predicted interference into another system from the Modified Kuiper System are nearly identical, but slightly reduced, compared to the predicted interference from the baseline Kuiper System. In addition, Amazon's analysis showed that the likelihood of inline events occurring between satellites in the Kuiper System and satellites in other NGSO systems is not impacted by these modifications. Thus, the proposed modification will not increase interference to other systems in the 2020 processing round or those licensed in prior processing rounds.

The *Kuiper System Authorization* included a condition requiring Amazon to complete coordination with operational NGSO systems authorized in prior processing rounds or to submit a showing that the Kuiper System will not cause harmful interference into such systems.[8] Amazon has already signed coordination agreements with Telesat LEO Inc. and Space Norway AS, the

[8] *See Kuiper System Authorization* ¶ 59(a).

status of which are unimpacted by this modification application. Moreover, Amazon is presently engaged in good-faith negotiations with the remaining NGSO FSS operators, and will continue coordination efforts consistent with this condition for the Modified Kuiper System.

D. Interference into the Kuiper System

While the proposed modifications to the Kuiper System do not increase its susceptibility to interference from other systems, Amazon will not seek protection from any additional interference that is a direct result of the proposed modifications.

IV. ORBITAL DEBRIS MITIGATION

On February 8, 2023, the Commission approved Amazon's orbital debris mitigation plan, which included detailed analyses regarding debris release, accidental explosions, collision risks, and post-mission disposal for the Kuiper System.[9] Since the Modified Kuiper System maintains the same altitude and inclination for 3,230 of the proposed modified 3,232 satellites, the proposed modifications will have no projected impact to the orbital debris assessments for these satellites. Accordingly, the information provided in connection with the Orbital Debris Modification Application[10] and approved by the Commission remains accurate and complete with respect to the 3,230 satellites.[11]

---

[9] *See Modification Order* ¶ 1.

[10] *See* Orbital Debris Modification Application.

[11] *See* Letter from Carrie Gage, Corporate Counsel, Kuiper Systems LLC, to Karl A. Kensinger, Chief, Satellite Division, International Bureau, FCC, IBFS File No. SAT-MOD-20211207-00186 (June 17, 2022); Consolidated Response of Kuiper Systems LLC, IBFS File No. SAT-MOD-20211207-00186 (July 12, 2022); Letter from Carrie Gage, Corporate Counsel, Kuiper Systems LLC, to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-MOD-20211207-00186 (Nov. 23, 2022).

The remaining two satellites that Amazon proposes to operate at 590 km altitude have a three-degree difference in inclination (30 degrees instead of 33 degrees for the rest of the shell). These two satellites are the ones described in Amazon's applications for experimental license,[12] which the Commission has granted.[13] In those filings, Amazon provided the necessary information about satellite design and operational strategies, including how Amazon will mitigate orbital debris risks for the satellites, demonstrating Amazon's compliance with the Commission's applicable rules on debris release and small debris, accidental explosions, collision risks with large objects, and post-mission disposal.[14]

---

[12] *See* Kuiper Systems LLC, Request for Experimental Authorization, Narrative, ELS File No. 0956-EX-CN-2021, Call Sign WM2XKY (filed Nov. 1, 2021); Kuiper Systems LLC, Request for Modification, ELS File No. 0234-EX-CM-2022, Call Sign WM2XKY (Oct. 10, 2022); *see also* Kuiper Systems LLC, Request for Experimental Authorization, Consolidated Response to OET Questions, ELS File No. 0956-EX-CN-2021, Call Sign WM2XKY (filed Feb. 1, 2022); Kuiper Systems LLC, Request for Experimental Authorization, Confidential ODAR, ELS File No. 0956-EX-CN-2021, Call Sign WM2XKY (filed Feb. 1, 2022); Kuiper Systems LLC, Request for Experimental Authorization, Space Safety Responses, ELS File No. 0956-EX-CN-2021, Call Sign WM2XKY (filed May 19, 2022); Kuiper Systems LLC, Request for Modification, Kuiper Response, ELS File No. 0234-EX-CM-2022, Call Sign WM2XKY (filed Nov. 18, 2022).

[13] *See* Kuiper Systems LLC, ELS File No. 0956-EX-CN-2021, Call Sign WM2XKY, Grant (June 9, 2022); Kuiper Systems LLC, 0234-EX-CM-2022, Call Sign WM2XKY, Grant (Jan. 27, 2023).

[14] *See* 47 C.F.R. § 25.114(d)(14). The filings for experimental license, although only referencing the Part 5 orbital debris mitigation rules, comply with the Commission's rules under both Part 5 and Part 25.

ENGINEERING CERTIFICATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this Application for Modification of Kuiper Systems LLC of Authorization for the Kuiper System, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in this application, and that it is complete and accurate to the best of my knowledge and belief.

<u>/s/ Paul Rosenberger</u>

Paul Rosenberger
Senior Regulatory Engineer
Kuiper Systems LLC

Date: February 28, 2023

ANNEX A. POTENTIAL INTERFERENCE WITH RESPECT TO OTHER NGSO SATELLITE SYSTEMS IN THE 2020 PROCESSING ROUND

Amazon designed the Kuiper System to maximize flexibility and efficient sharing with other NGSO systems. In accordance with the *Teledesic*[15] standard, Amazon performed simulations and analyses against other NGSO satellite systems in the 2020 processing round to demonstrate that the Modified Kuiper System will not increase interference into those systems as compared to the Kuiper System. Amazon's analyses assess the Modified Kuiper System in both uplink and downlink scenarios, and consider both Kuiper Gateway ("GW") and Customer Terminal ("CT") cases against five proposed NGSO systems (the "Test Systems") shown in Table A.1, below.

Table A.1: 2020 Processing Round Systems Included in Interference Analysis

2020 Processing Round System	Number of Satellites	Orbit Regime	Minimum Elevation Angle
O3b	112	LEO/MEO	5°
OneWeb	6372	LEO	15°
SpaceX	7500[16]	LEO	25°
Telesat	1671	LEO	10°
Viasat	288	LEO	25°

Specifically, Amazon's simulations and analyses examine the power received into other systems' receivers as a result of transmissions by the Modified Kuiper System or Kuiper System. The simulations propagate satellites over a significantly long duration to be statistically relevant, produce possible satellites to ground user link options at each time step based on each system's

[15] *Teledesic LLC*, Order and Authorization, 14 FCC Rcd 2261 (IB 1999).

[16] Amazon selected 2500 satellites from each of the approved orbital shells in the partial grant of SpaceX's Gen2 system. *See Space Exploration Holdings, LLC, Request for Orbital Deployment and Operating Authority for the SpaceX Gen2 NGSO Satellite System*, Order and Authorization, FCC 22-91 (rel. Dec. 1, 2022).

coverage constraints, and then randomly select the satellites to ground links at each time step to compute the interference-to-noise ("I/N") ratio. The resulting I/N data is analyzed statistically and expressed as Cumulative Distribution Functions ("CDF"). Other system parameters (such as orbital parameters, minimum elevation angle, and antenna characteristics) were pulled from appropriate Commission filings for the Test Systems, such as the Schedule S or the technical narratives associated with their respective authorizations. For earth station information, parameters were pulled from ITU filing submissions related to the Test Systems. In cases where there were many filed configurations (i.e., earth stations), Amazon analyzed a subset of cases in order to bound the analysis results. Because Amazon did not implement any interference mitigation techniques in any simulation, the results of these simulations reflect the worst-case scenarios.

The interference simulation results provided below demonstrate that the proposed modification will not worsen the predicted interference environment. The results show that the proposed modification will not impact the likelihood of exceeding the Commission's -12.2 dB I/N threshold that triggers the default sharing procedure under Section 25.261(c) of the Commission's rules. In all cases, the results look nearly identical for most of the curve. In the few cases where the results diverge slightly, they do so only at the lowest probabilities and high I/N values. These deviations are explained by statistical variation due to the low number of occurrences of these events in the simulation. In the rare instances when two systems of equal priority have large predicted I/N values, the potential interference will be resolved through coordination or else require band-splitting under the FCC's default sharing procedure.

Amazon performed the following interference analysis procedure:

1. A Kuiper Customer Terminal or a Kuiper Gateway is collocated with other system's earth station at 40°N[17].
2. The victim system's earth station communicates with any satellite in its own system as long as it is above their specified coverage constraints (i.e., minimum elevation angle).
3. Kuiper places one co-frequency beam at a user cell (for the CT case) and up to four co-frequency beams at a Gateway location (for the GW case). Random satellites above Kuiper's minimum elevation angle (20° for gateways, 35° for customer terminals) are chosen to generate beams. The random selection is chosen due to the statistical nature of the simulation.
4. RF propagation and antenna gain calculations determine interference into victim receivers:
    a. For Uplink cases, a Kuiper Low Gain CT, Kuiper High Gain CT, or Kuiper GW point (or steer beams) to the selected Kuiper System satellites, transmit at their maximum Equivalent, Isotropically Radiated Power ("EIRP") density, and the interference is measured at the receiver of the victim satellites.
    b. For Downlink cases, the selected Kuiper System satellites transmit to a Kuiper CT or Kuiper GW and the interference is measured at the receiver of the victim earth stations assuming the victim earth station points (or steers beams) to the selected victim satellites.

[17] Amazon ran simulations for multiple earth station latitudes within the Kuiper System area. The results were similar for each latitude.

5. The results for each case are compiled and expressed as a CDF. Results for the original Kuiper System constellation and the Modified Kuiper System constellation are plotted on top of one another for comparison.

A1. O3b

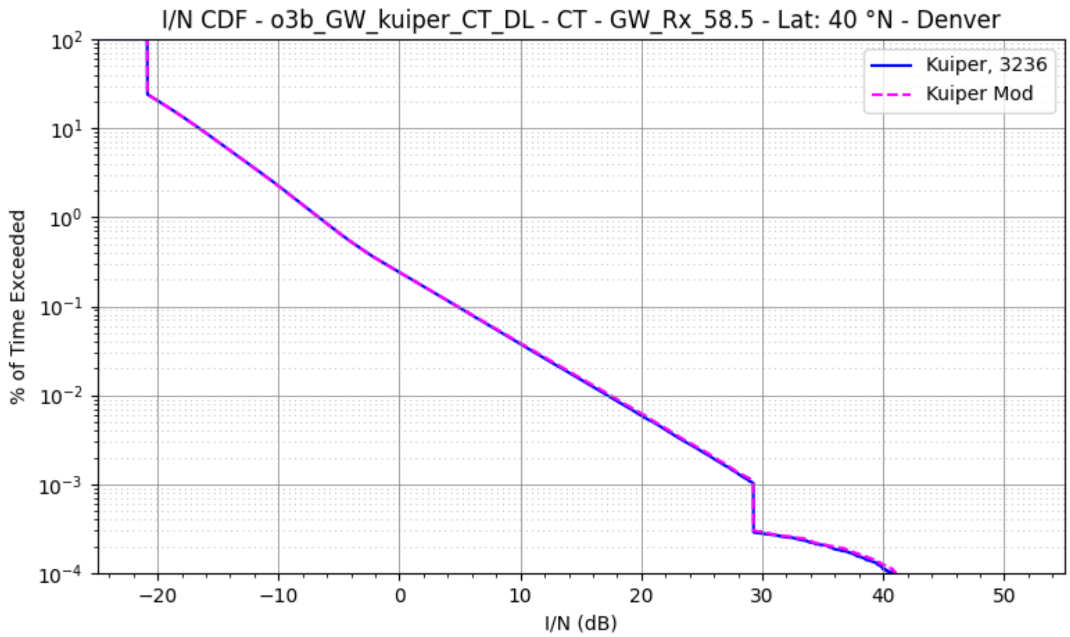


Figure A1.1: Kuiper CT Downlink Beam into O3b Terminal, Rx Peak Gain: 58.5 dBi

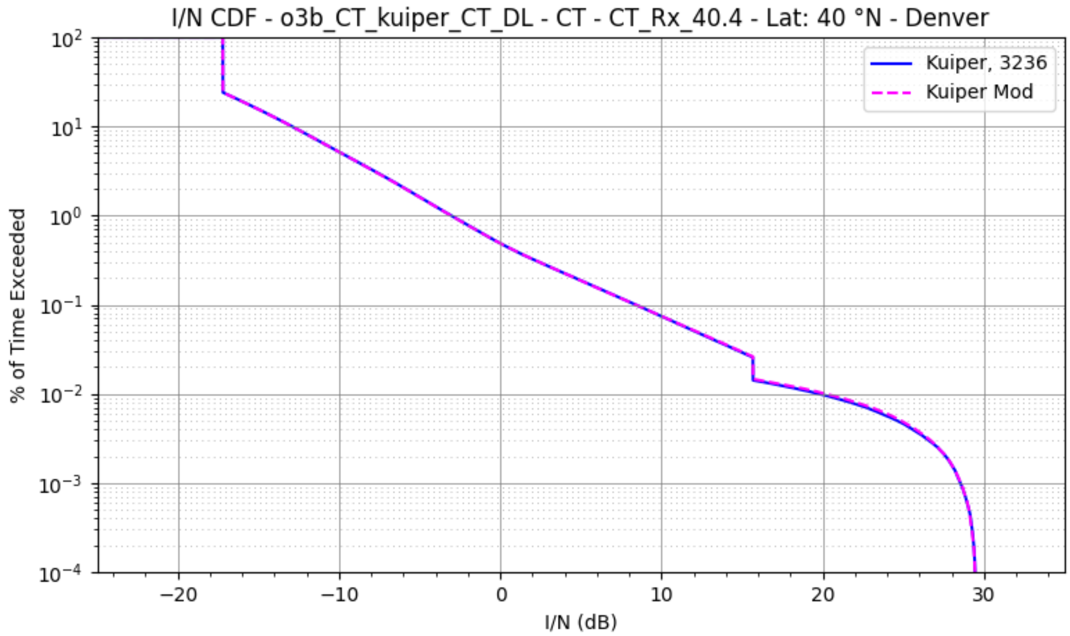


Figure A1.2: Kuiper CT Downlink Beam into O3b Terminal, Rx Peak Gain: 40.4 dBi

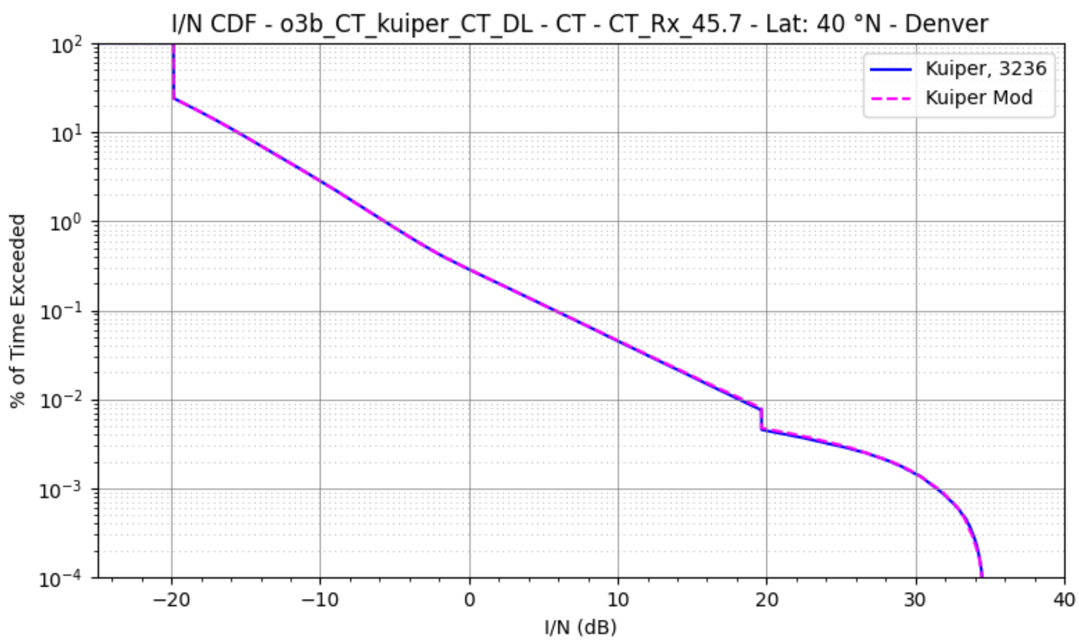


Figure A1.3: Kuiper CT Downlink Beam into O3b Terminal, Rx Peak Gain: 45.7 dBi

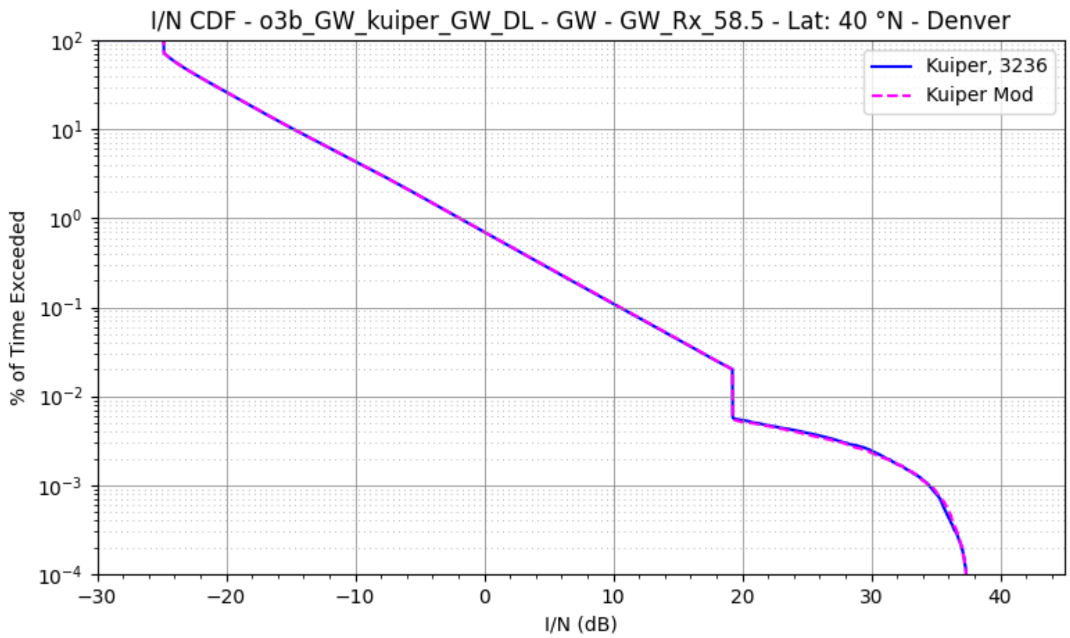


Figure A1.4: Kuiper GW Downlink Beam into O3b Terminal, Rx Peak Gain: 58.5 dBi

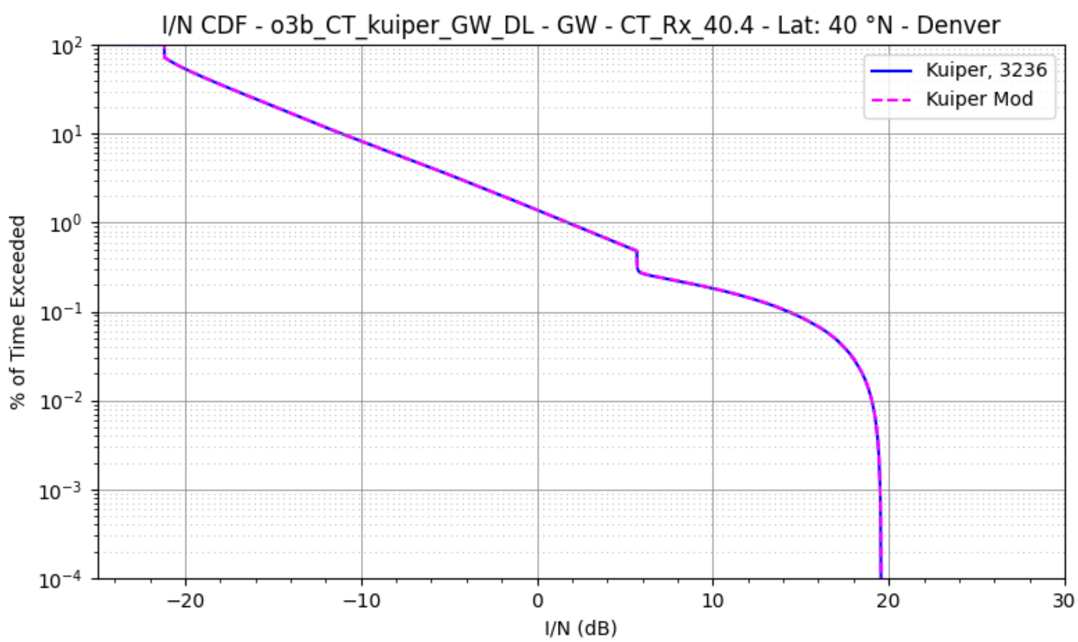


Figure A1.5: Kuiper GW Downlink Beam into O3b Terminal, Rx Peak Gain: 40.4 dBi

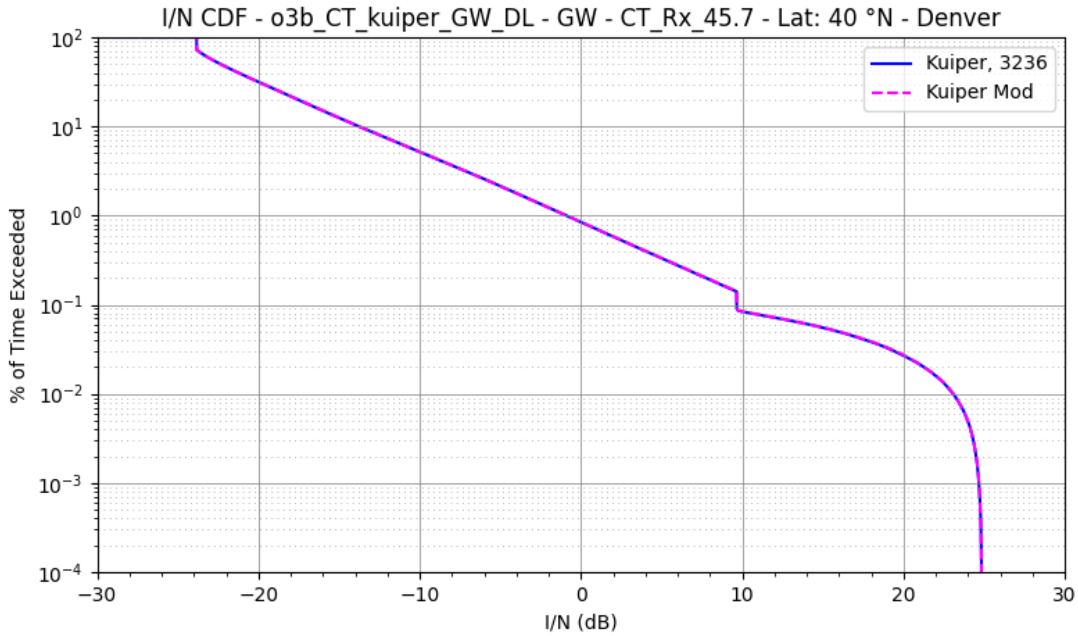


Figure A1.6: Kuiper GW Downlink Beam into O3b Terminal, Rx Peak Gain: 45.7 dBi

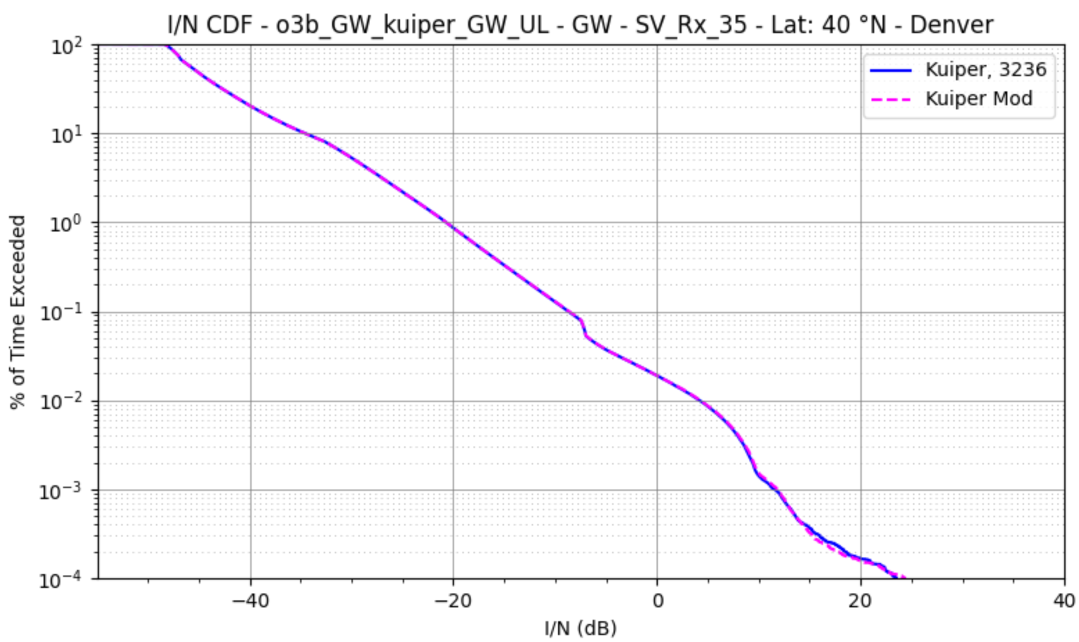


Figure A1.7: Kuiper GW Uplink into O3b Satellite, Rx Peak Gain: 35 dBi

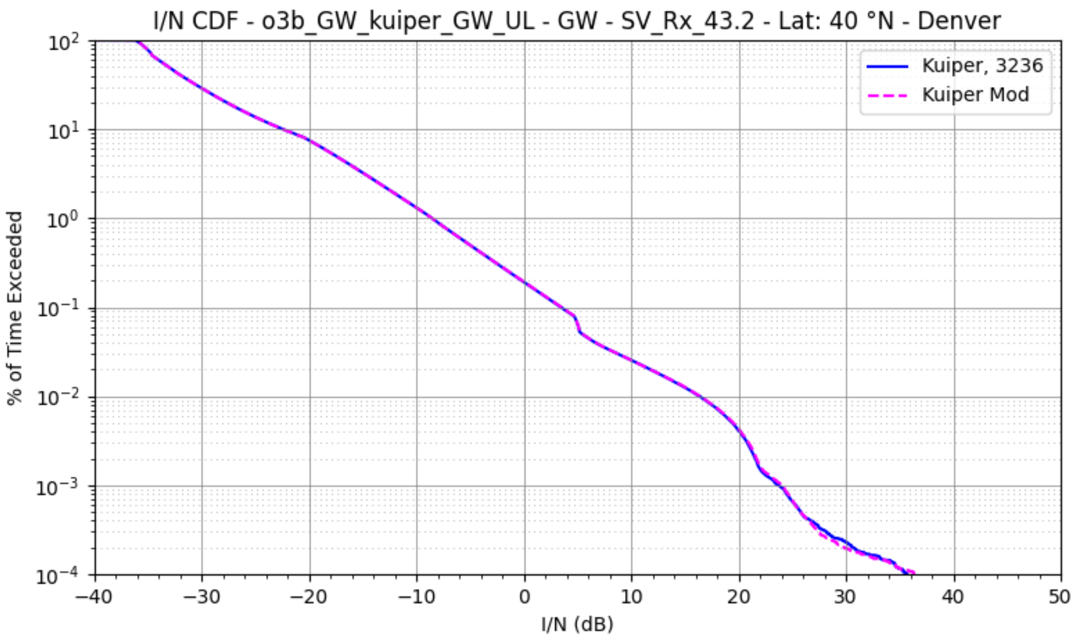


Figure A1.8: Kuiper GW Uplink into O3b Satellite, Rx Peak Gain: 43.2 dBi

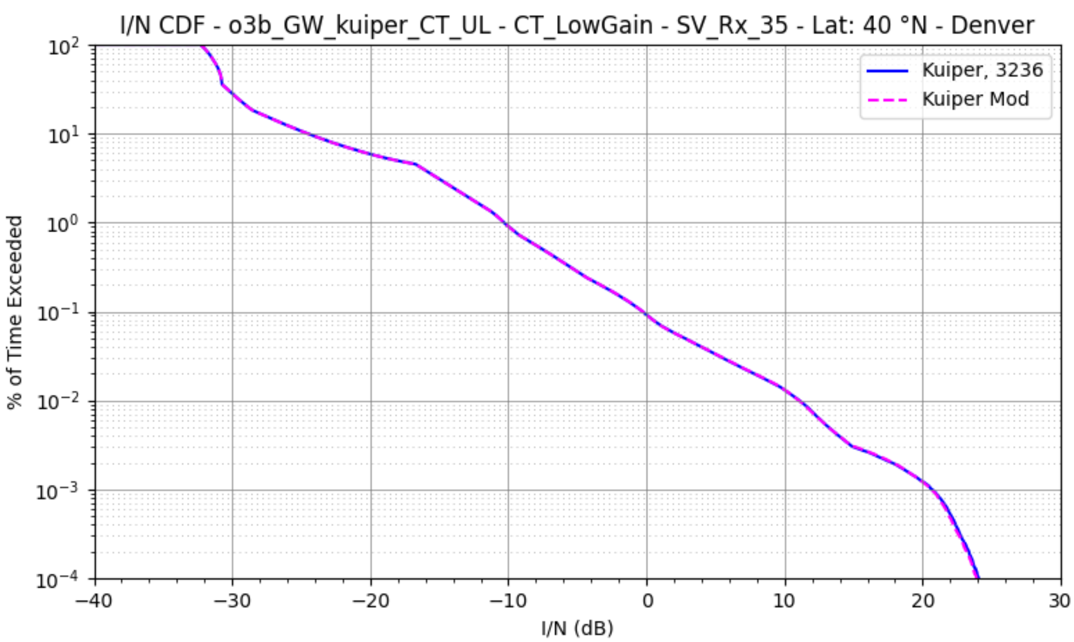


Figure A1.9: Kuiper Low Gain CT Uplink into O3b Satellite, Rx Peak Gain: 35 dBi

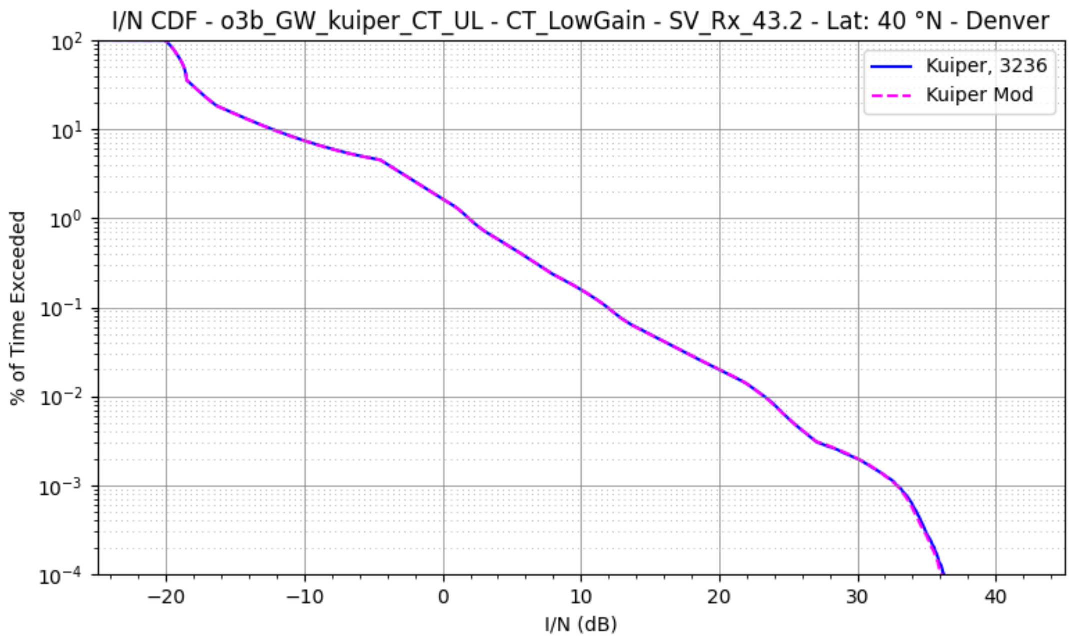


Figure A1.10: Kuiper Low Gain CT Uplink into O3b Satellite, Rx Peak Gain: 43.2 dBi

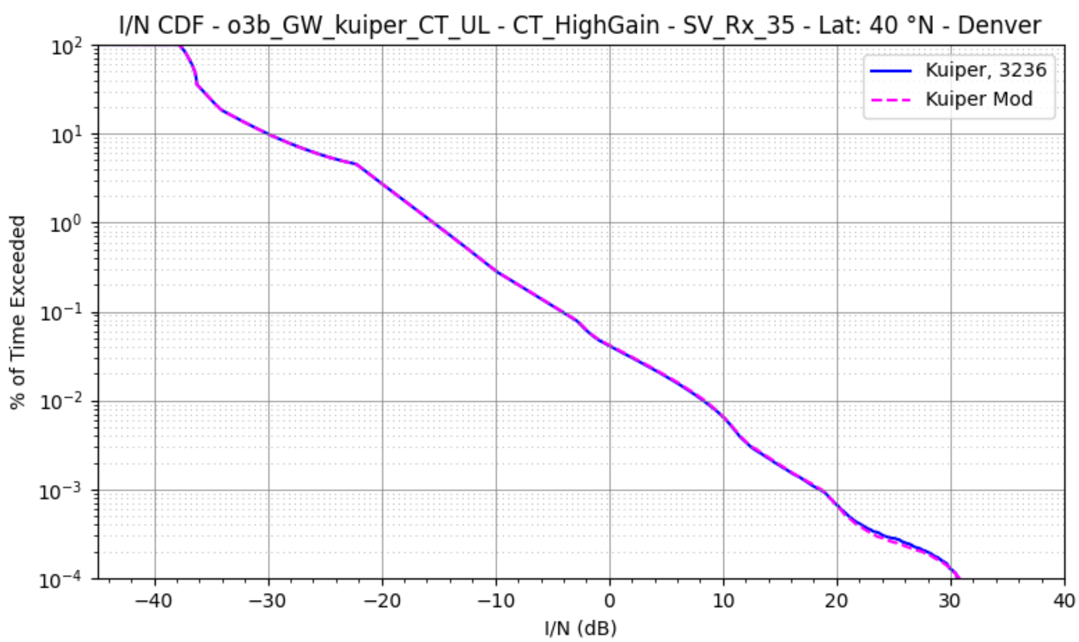


Figure A1.11: Kuiper High Gain CT Uplink into O3b Satellite, Rx Peak Gain: 35 dBi

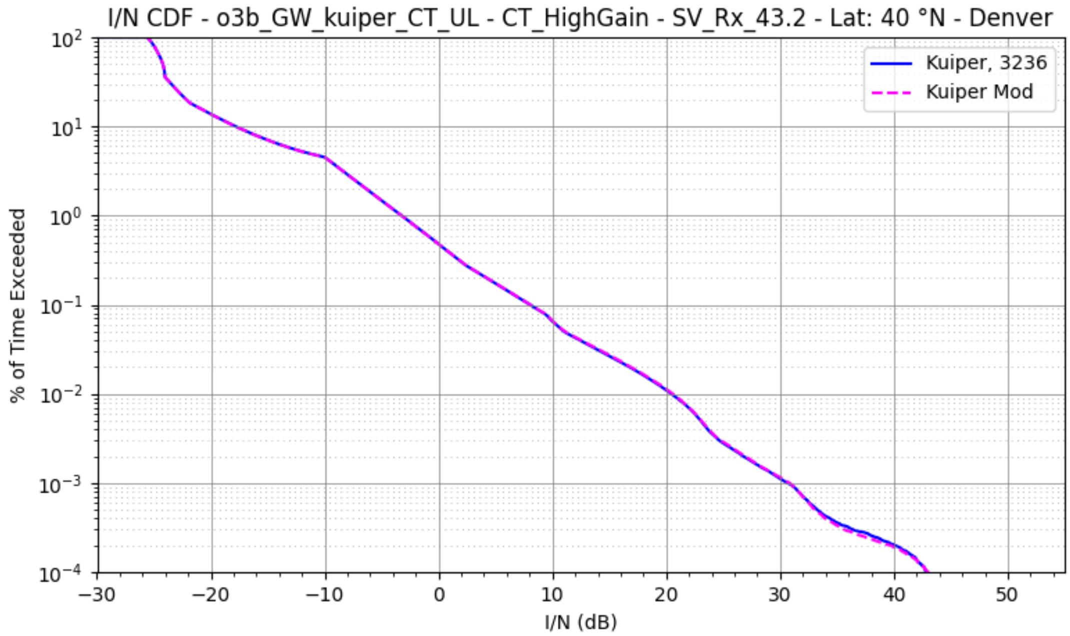


Figure A1.12: Kuiper High Gain CT Uplink into O3b Satellite, Rx Peak Gain: 43.2 dBi

A2. OneWeb

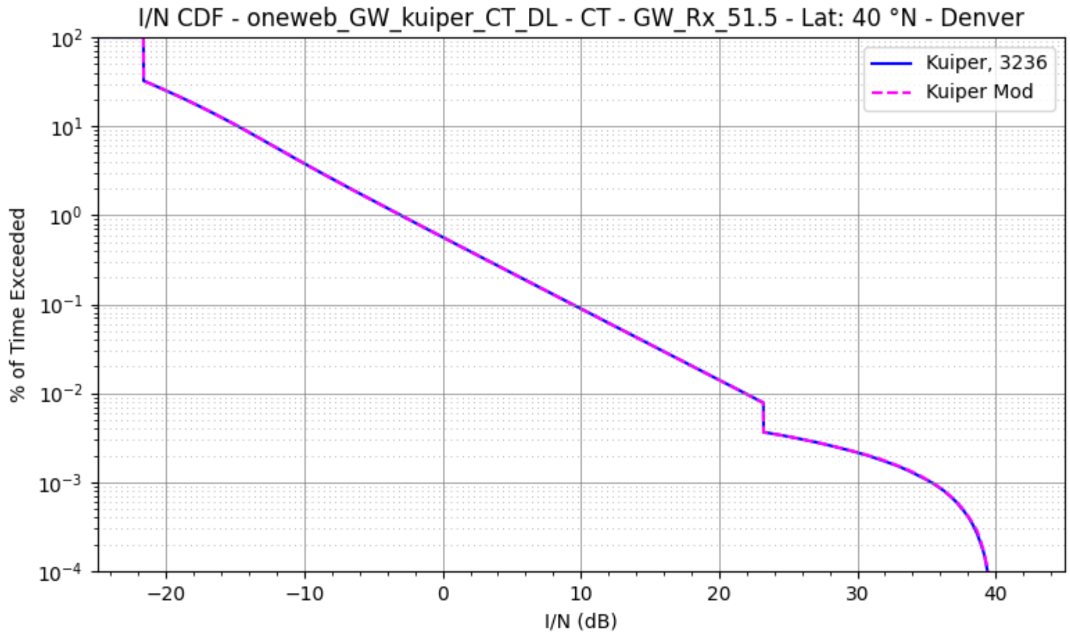


Figure A2.1: Kuiper CT Downlink Beam into OneWeb Terminal, Rx Peak Gain: 51.5 dBi

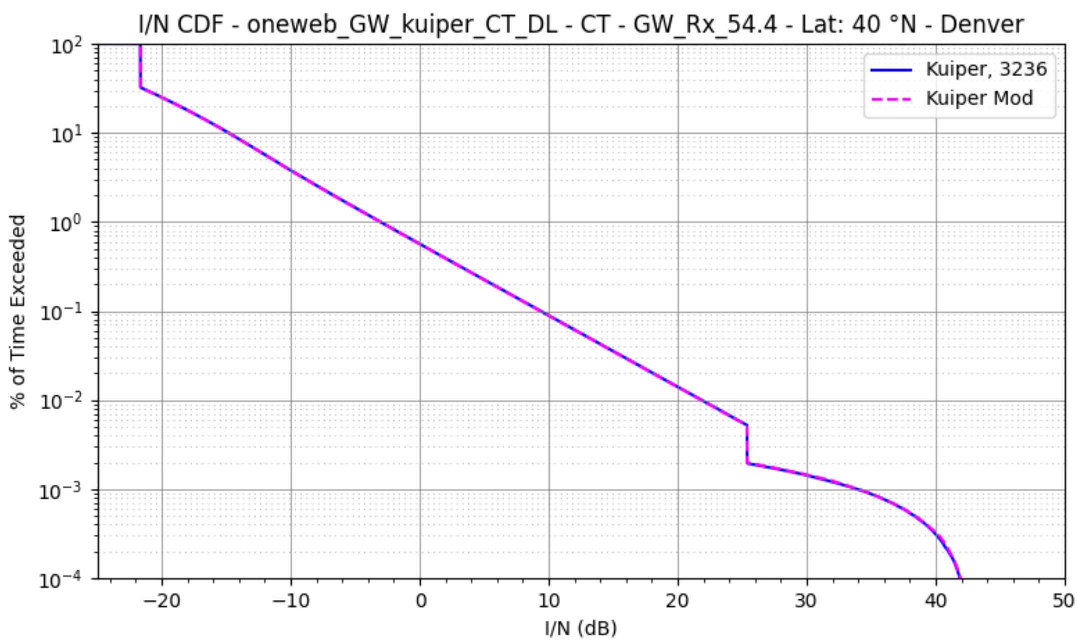


Figure A2.2: Kuiper CT Downlink Beam into OneWeb Terminal, Rx Peak Gain: 54.4 dBi

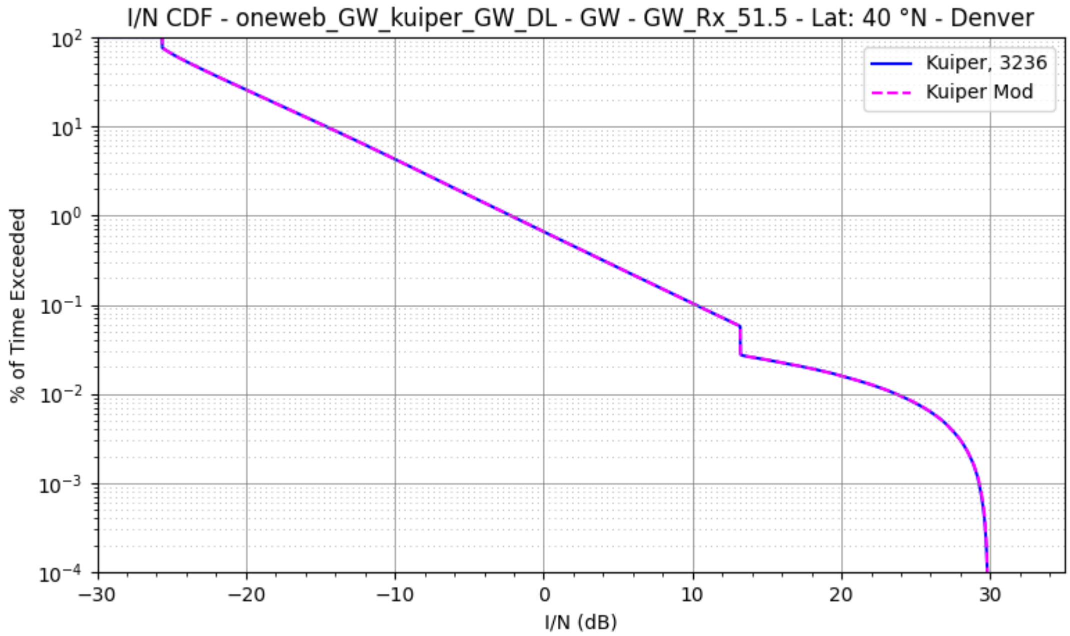


Figure A2.3: Kuiper GW Downlink Beam into OneWeb Terminal, Rx Peak Gain: 51.5 dBi

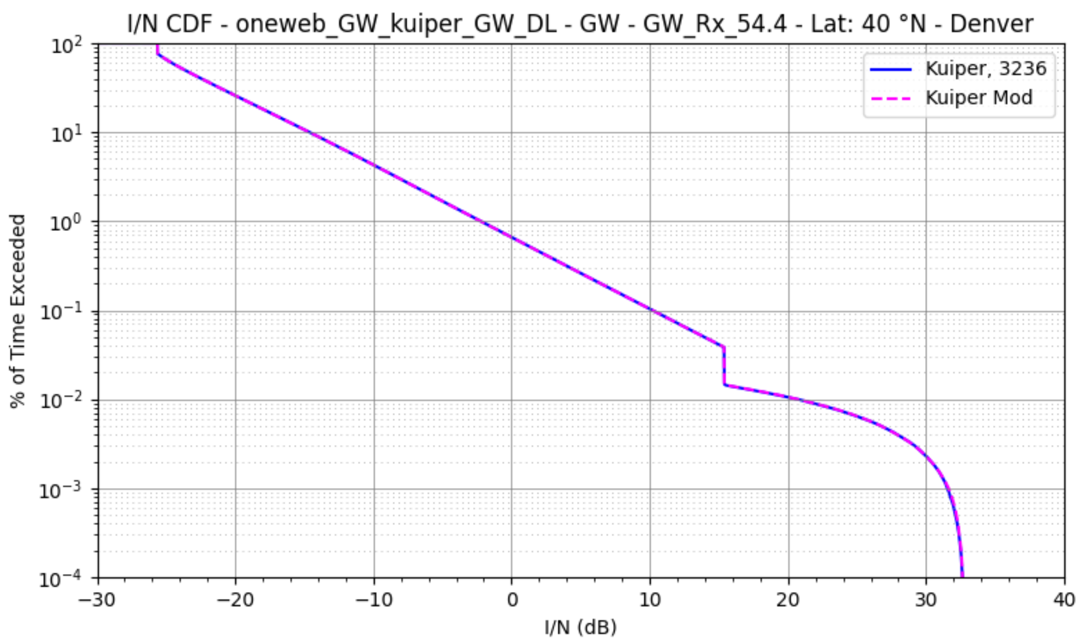


Figure A2.4: Kuiper GW Downlink Beam into OneWeb Terminal, Rx Peak Gain: 54.4 dBi

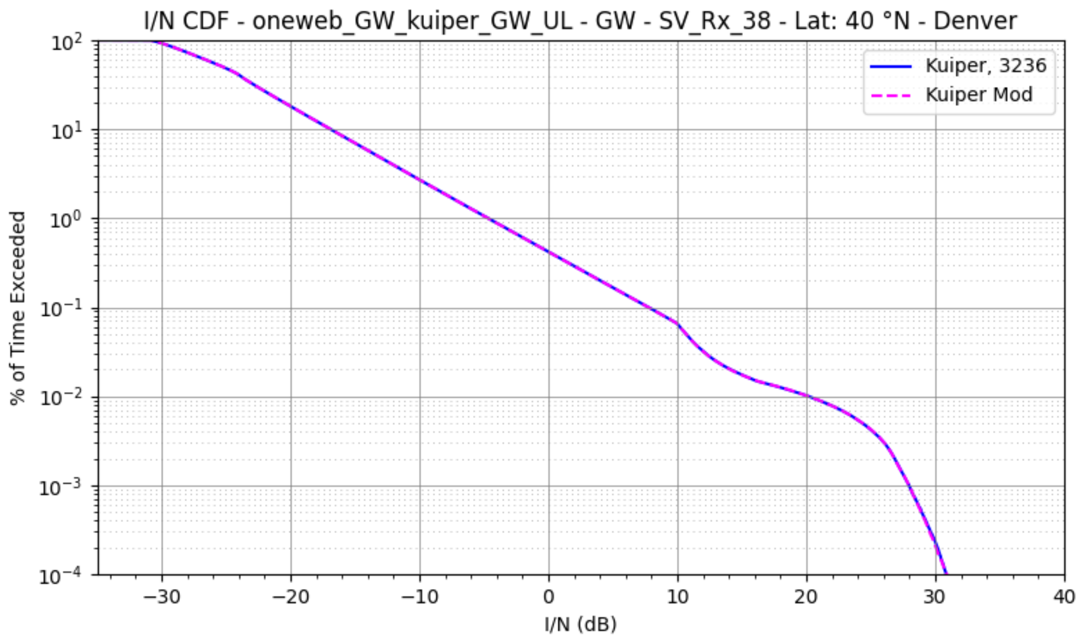


Figure A2.5: Kuiper GW Uplink into OneWeb Satellite, Rx Peak Gain: 38 dBi

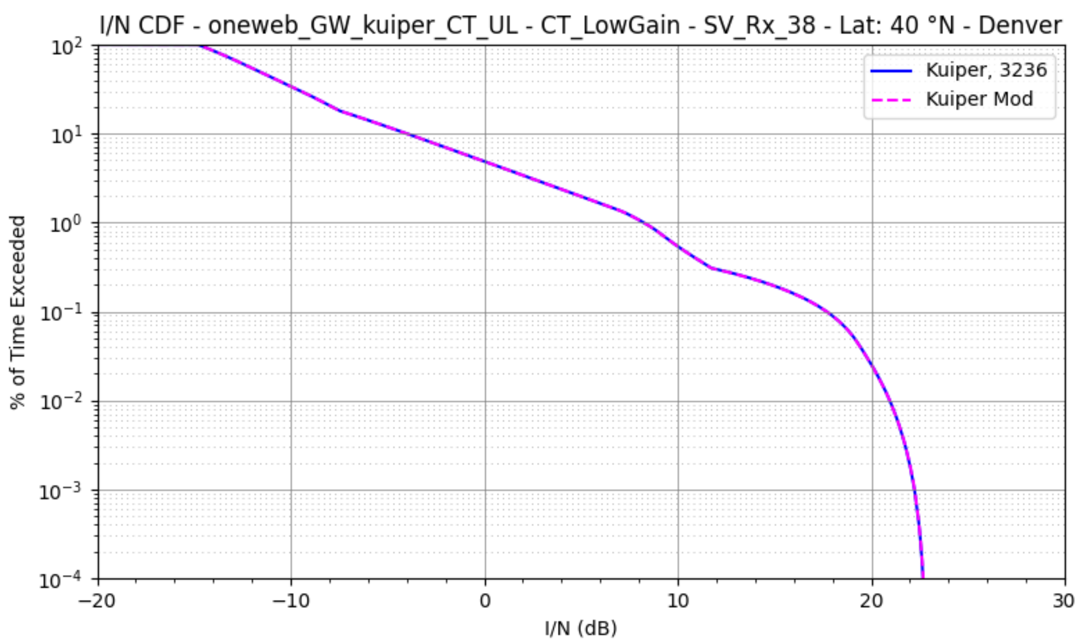


Figure A2.6: Kuiper Low Gain CT Uplink into OneWeb Satellite, Rx Peak Gain: 38 dBi

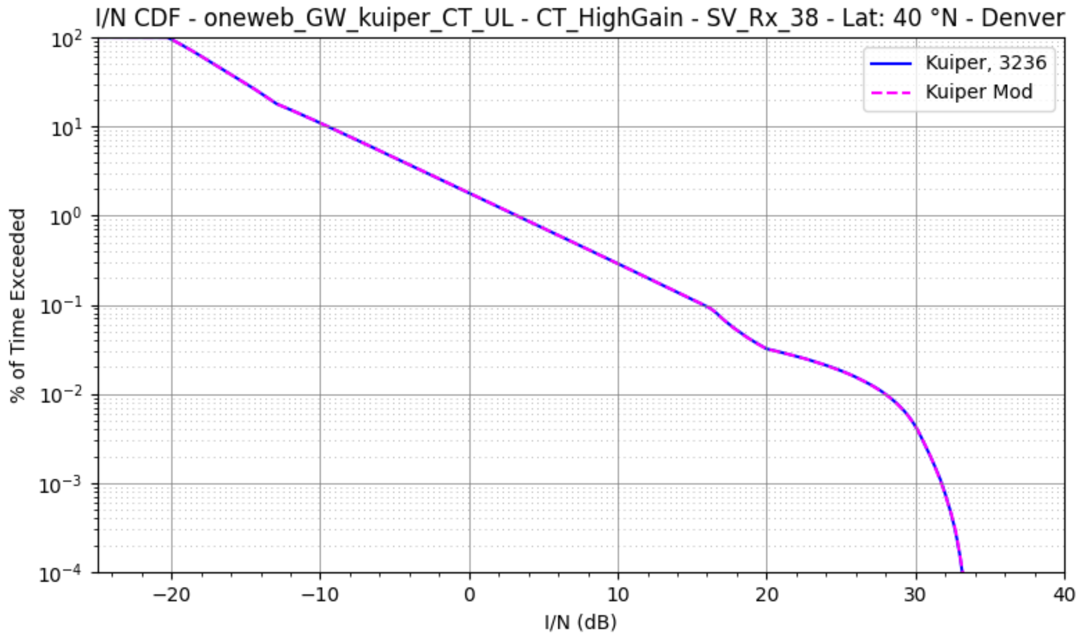


Figure A2.7: Kuiper High Gain CT Uplink into OneWeb Satellite, Rx Peak Gain: 38 dBi

A3. SpaceX

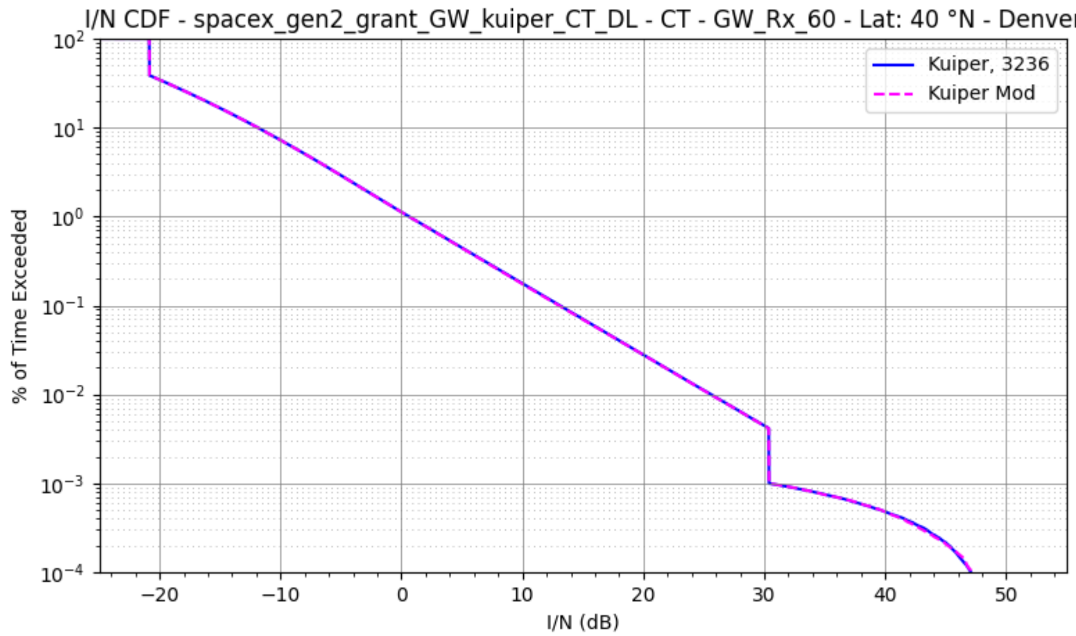


Figure A3.1: Kuiper CT Downlink Beam into SpaceX Terminal, Rx Peak Gain 60 dBi

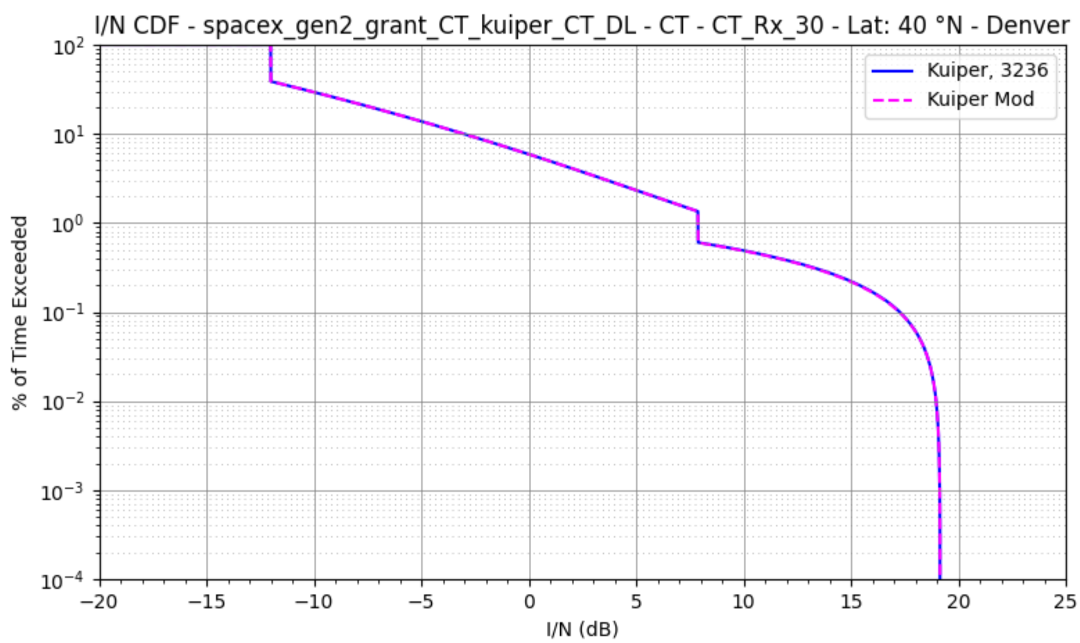


Figure A3.2: Kuiper CT Downlink Beam into SpaceX Terminal, Rx Peak Gain 30 dBi

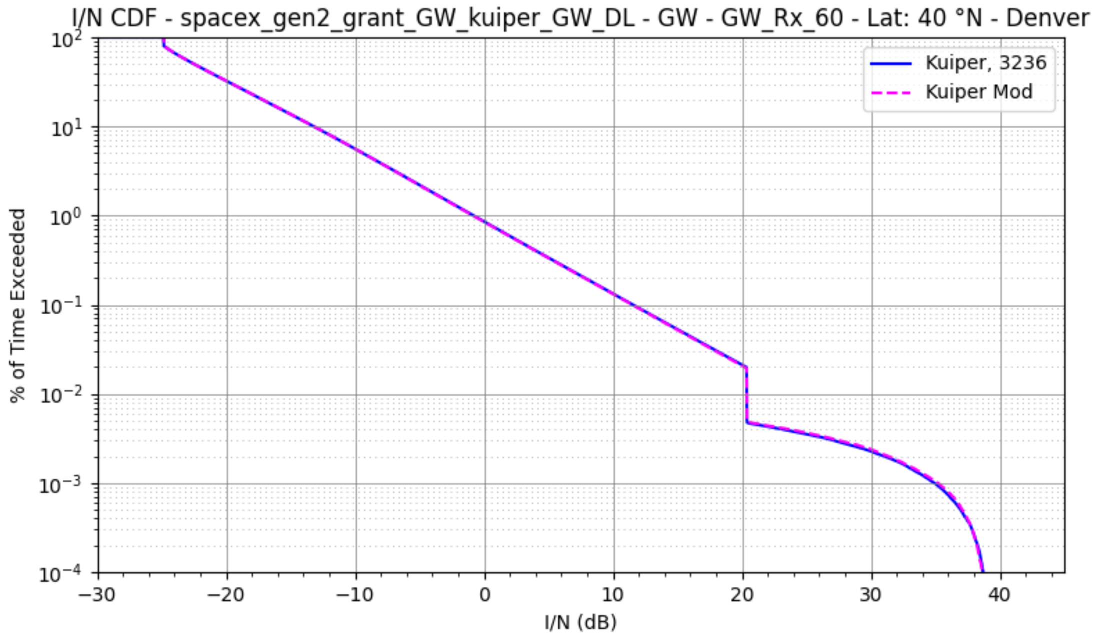


Figure A3.3: Kuiper GW Downlink Beam into SpaceX Terminal, Rx Peak Gain 60 dBi

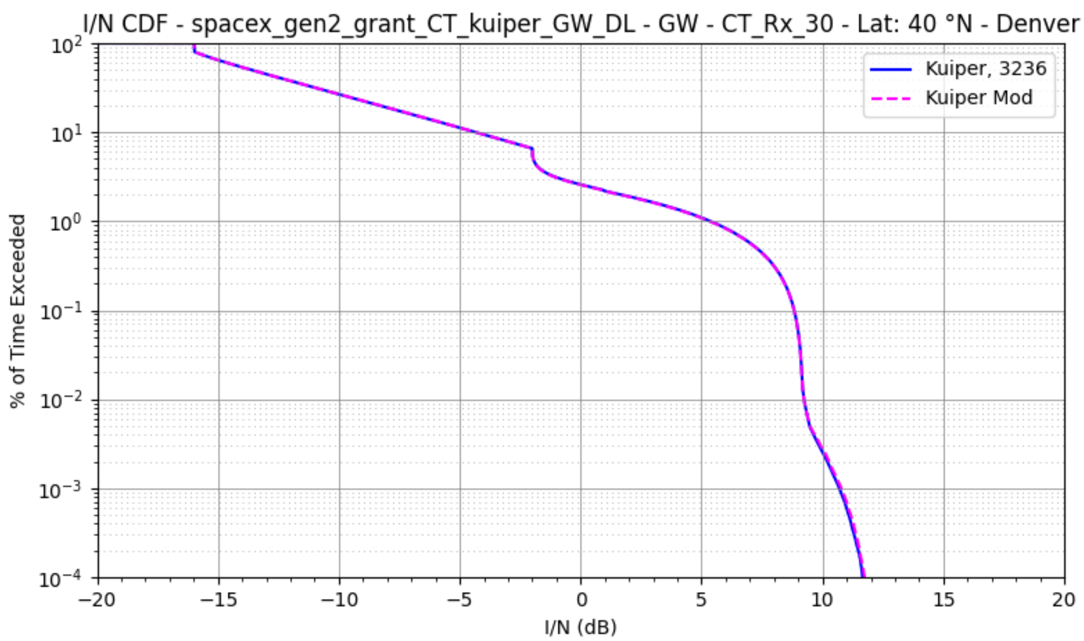


Figure A3.4: Kuiper GW Downlink Beam into SpaceX Terminal, Rx Peak Gain 30 dBi

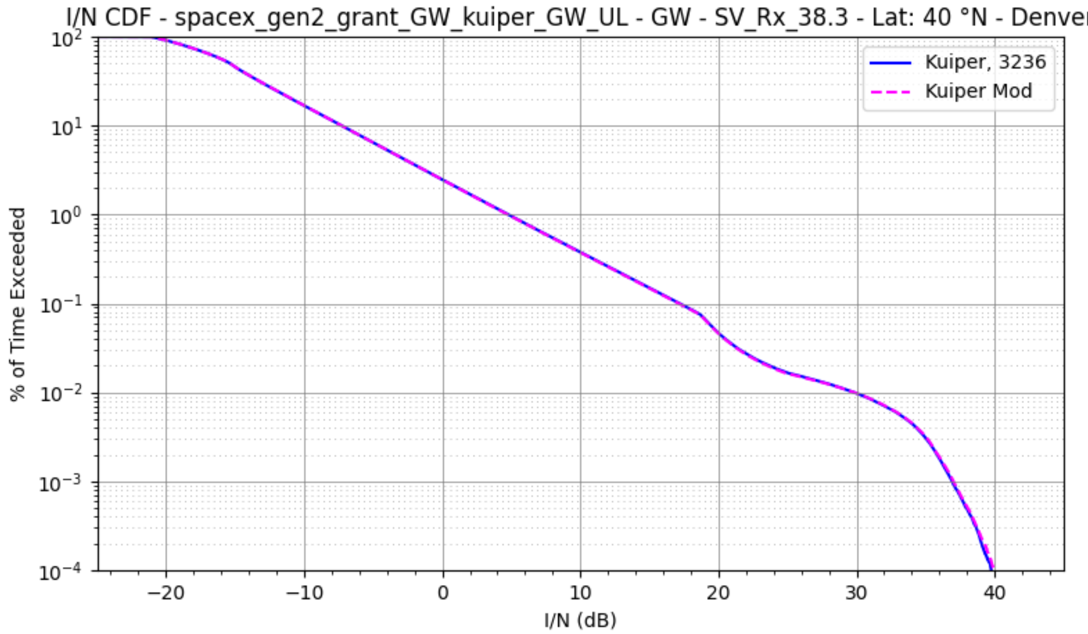


Figure A3.5: Kuiper GW Uplink into SpaceX Satellite, Rx Peak Gain: 38.3 dBi

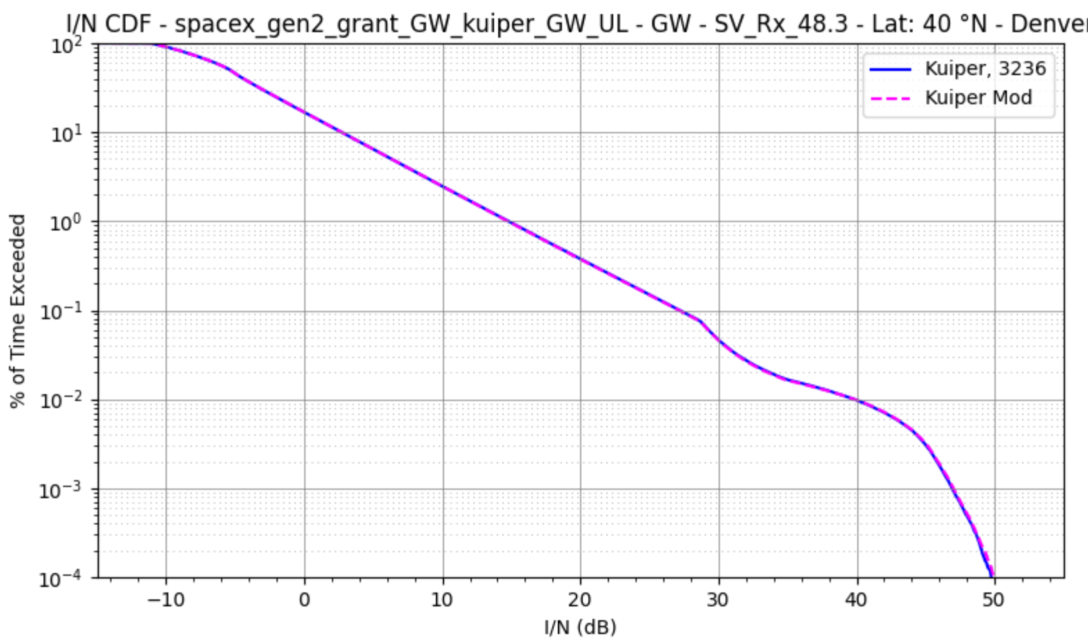


Figure A3.6: Kuiper GW Uplink into SpaceX Satellite, Rx Peak Gain: 48.3 dBi

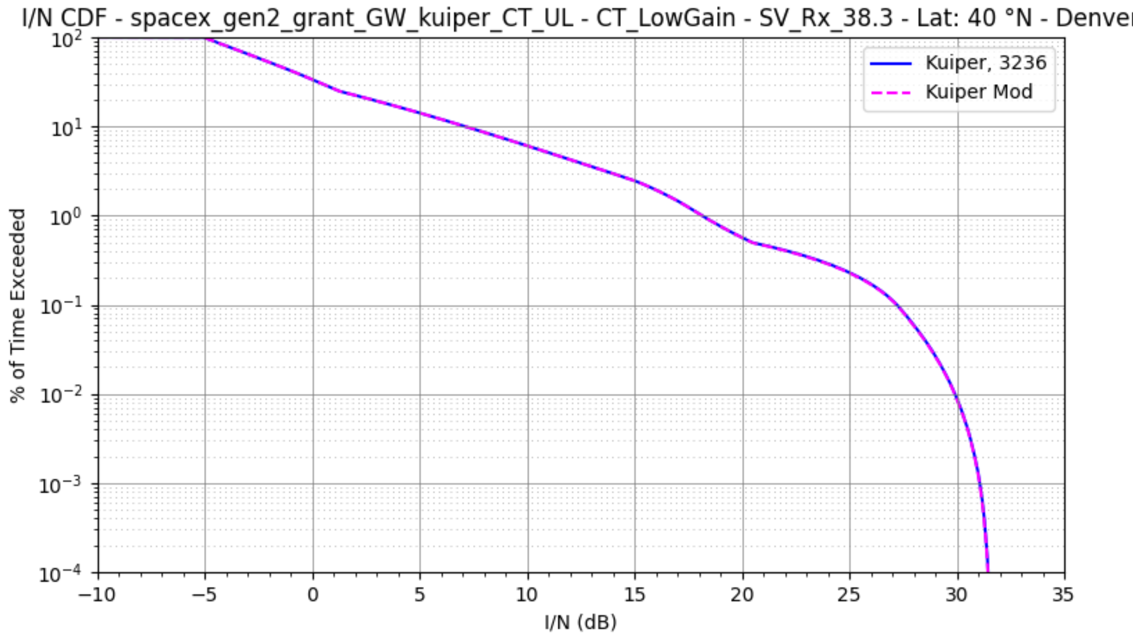


Figure A3.7: Kuiper Low Gain CT Uplink into SpaceX Satellite, Rx Peak Gain: 38.3 dBi

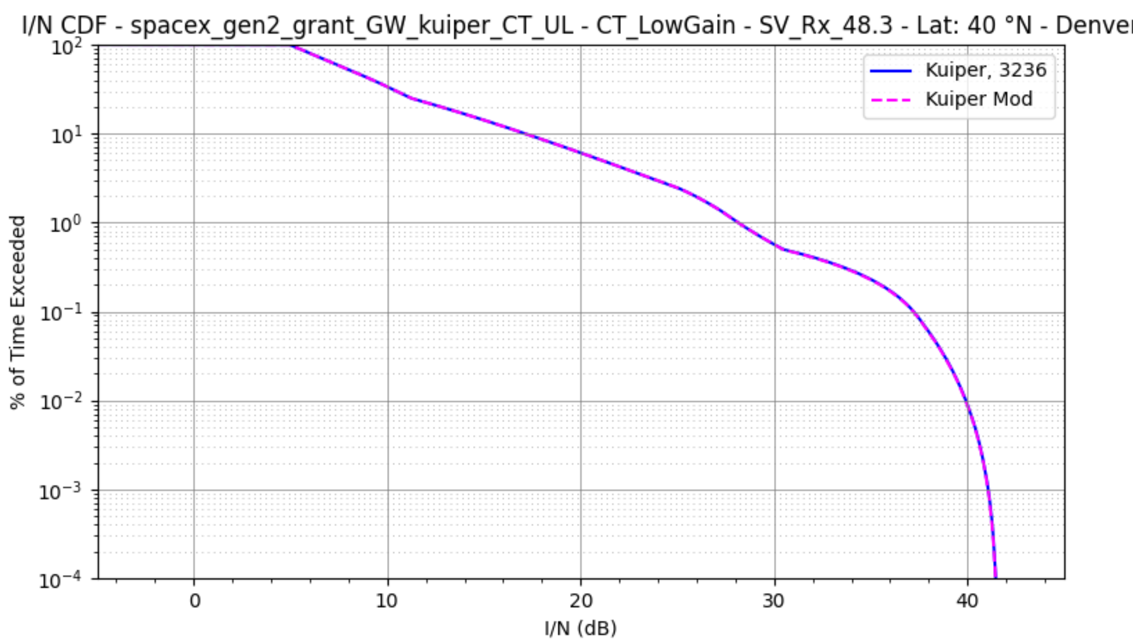
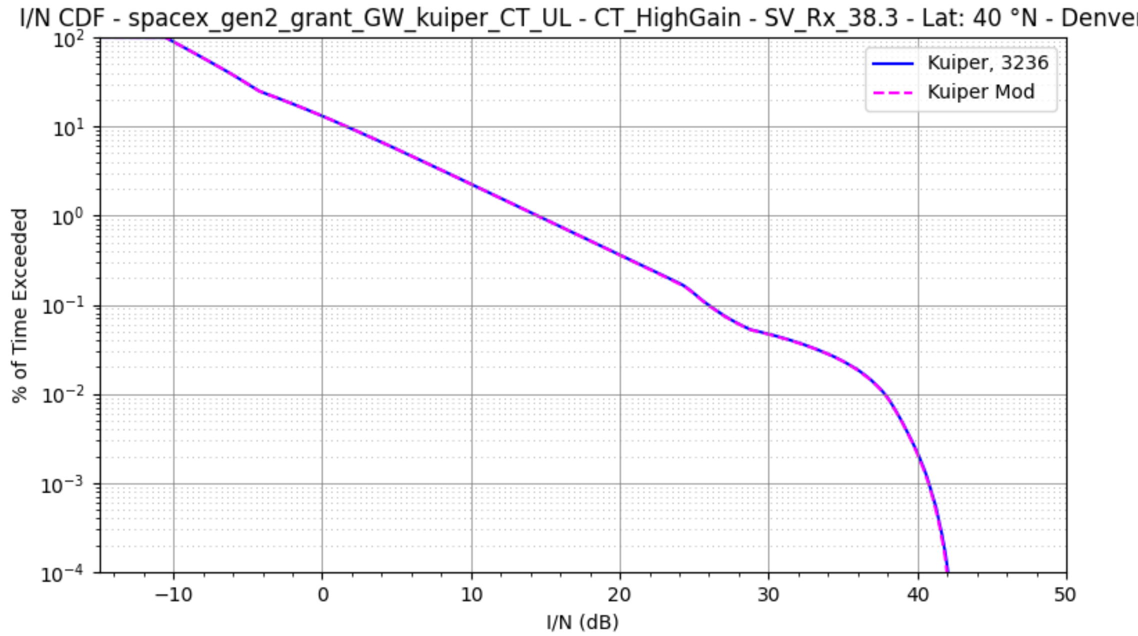
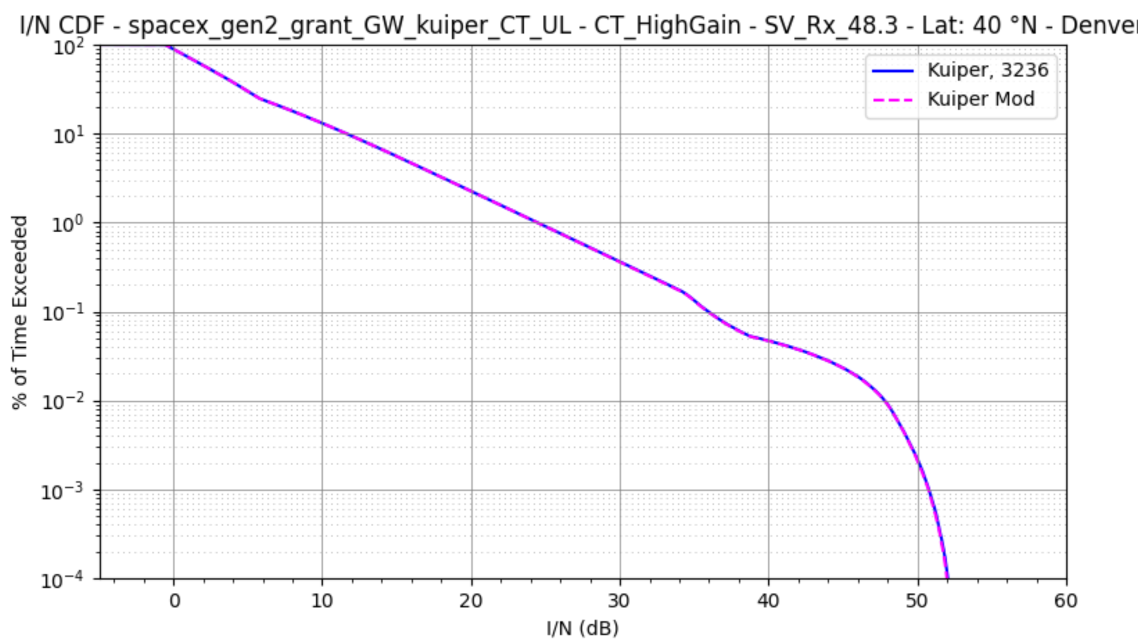


Figure A3.8: Kuiper Low Gain CT Uplink into SpaceX Satellite, Rx Peak Gain: 48.3 dBi



<u>Figure A3.9</u>: Kuiper High Gain CT Uplink into SpaceX Satellite, Rx Peak Gain: 38.3 dBi



<u>Figure A3.10</u>: Kuiper High Gain CT Uplink into SpaceX Satellite, Rx Peak Gain: 48.3 dBi

A4. Telesat

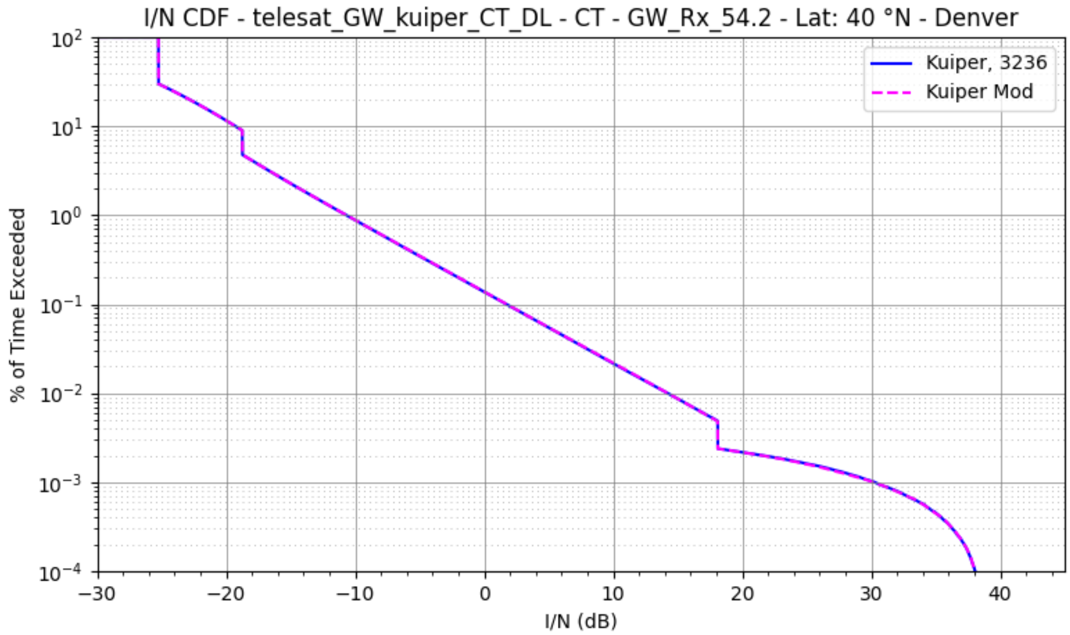


Figure A4.1: Kuiper CT Downlink Beam into Telesat Terminal, Rx Peak Gain: 54.2 dBi

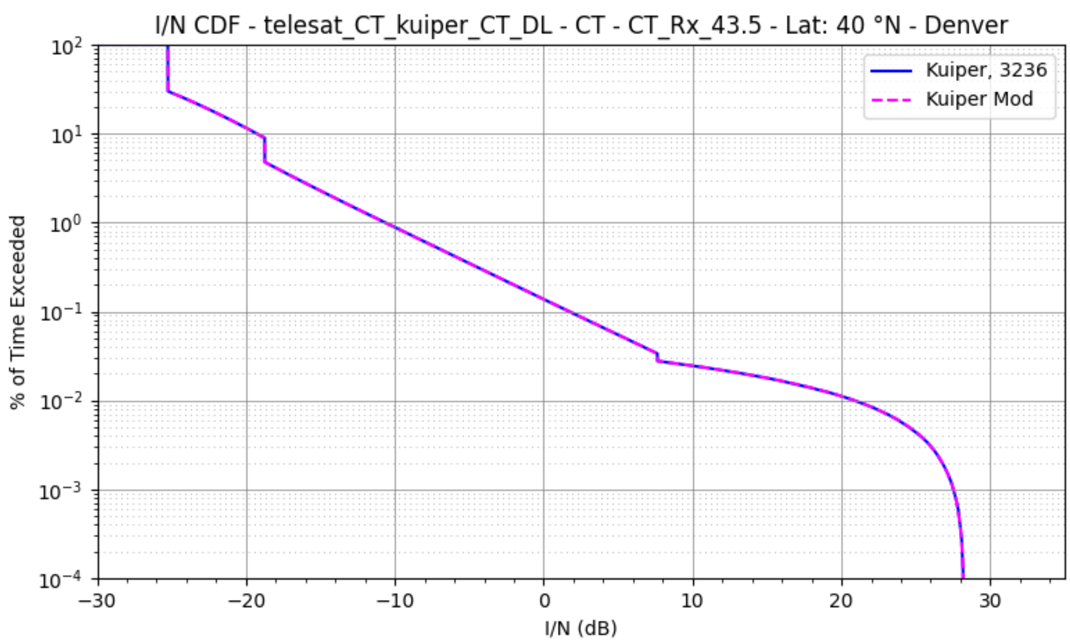


Figure A4.2: Kuiper CT Downlink Beam into Telesat Terminal, Rx Peak Gain: 43.5 dBi

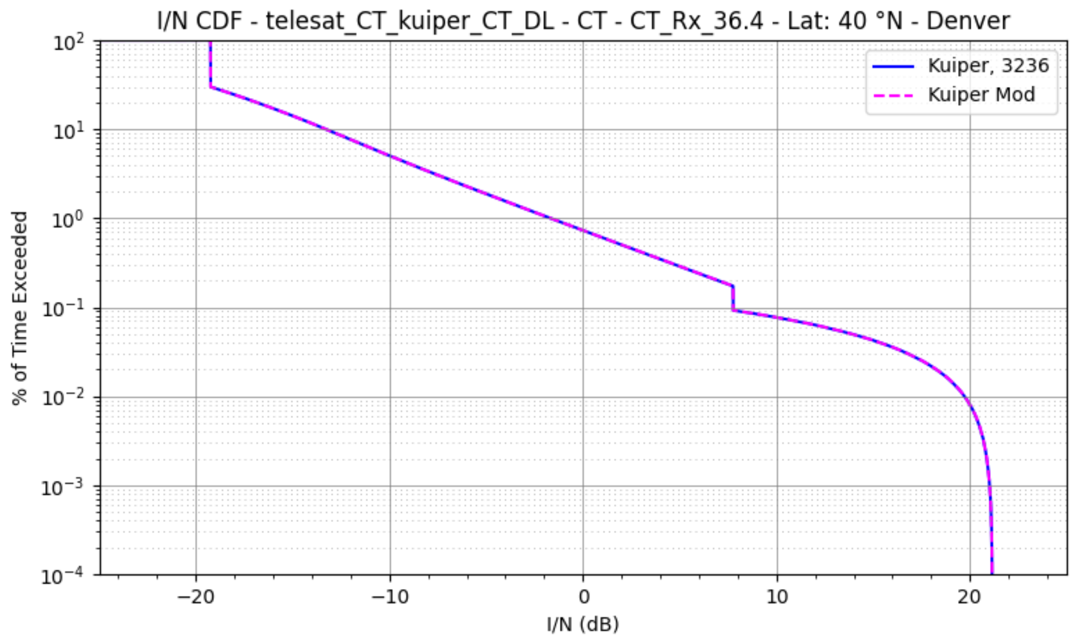


Figure A4.3: Kuiper CT Downlink Beam into Telesat Terminal, Rx Peak Gain: 36.4 dBi

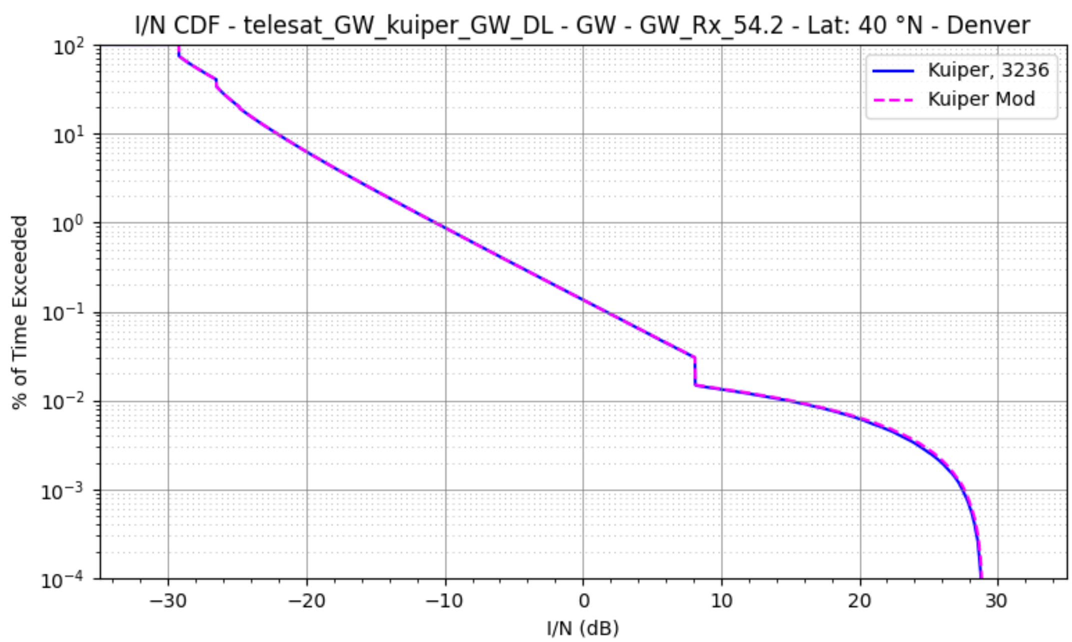


Figure A4.4: Kuiper GW Downlink Beam into Telesat Terminal, Rx Peak Gain: 54.2 dBi

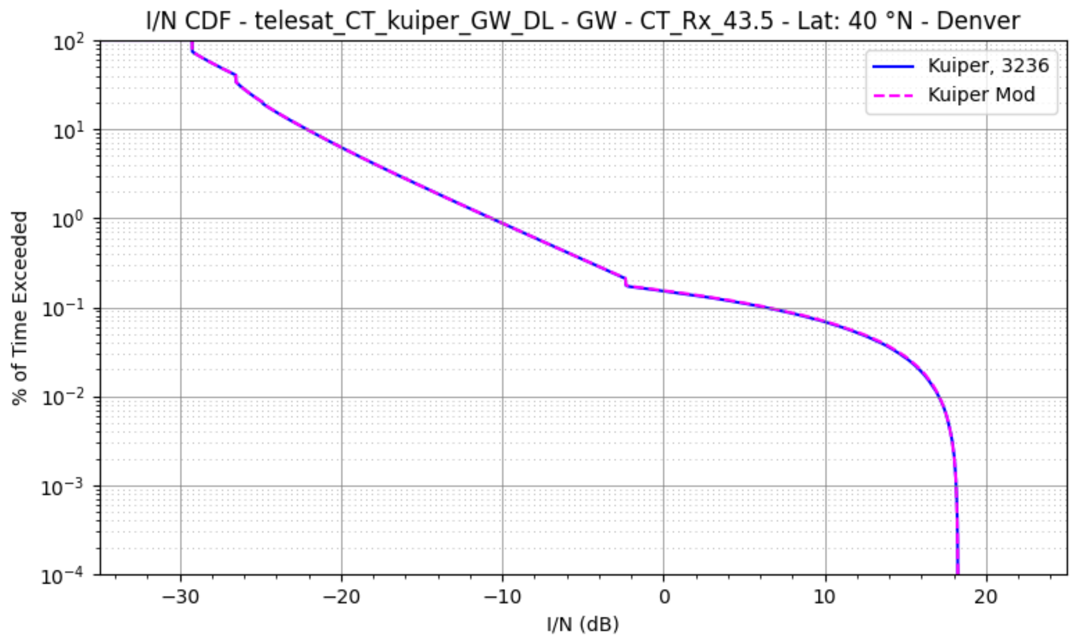


Figure A4.5: Kuiper GW Downlink Beam into Telesat Terminal, Rx Peak Gain: 43.5 dBi

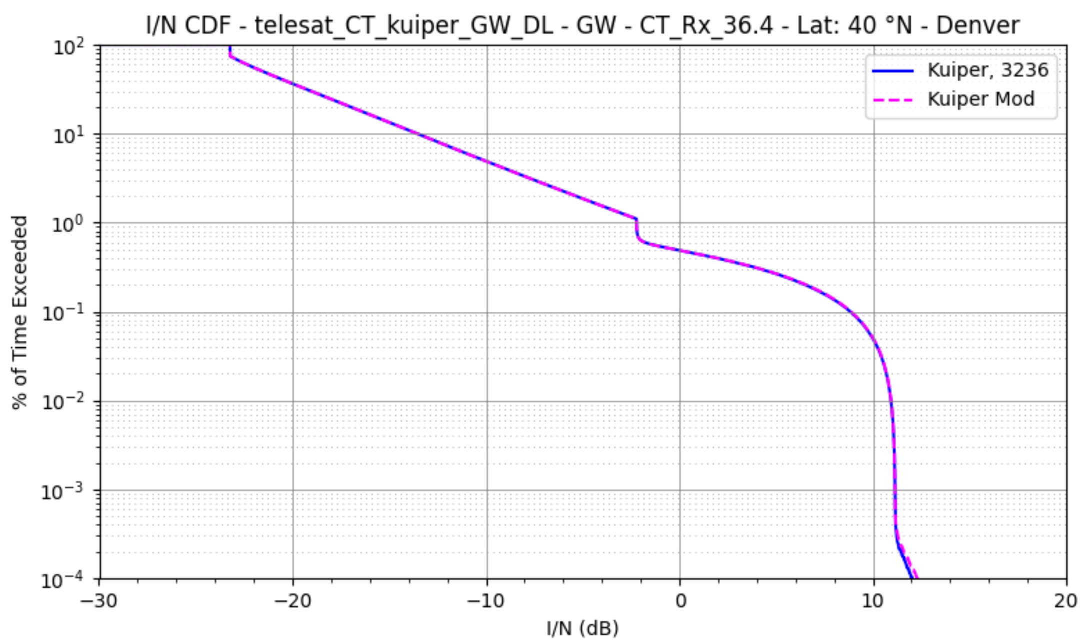


Figure A4.6: Kuiper GW Downlink Beam into Telesat Terminal, Rx Peak Gain: 36.4 dBi

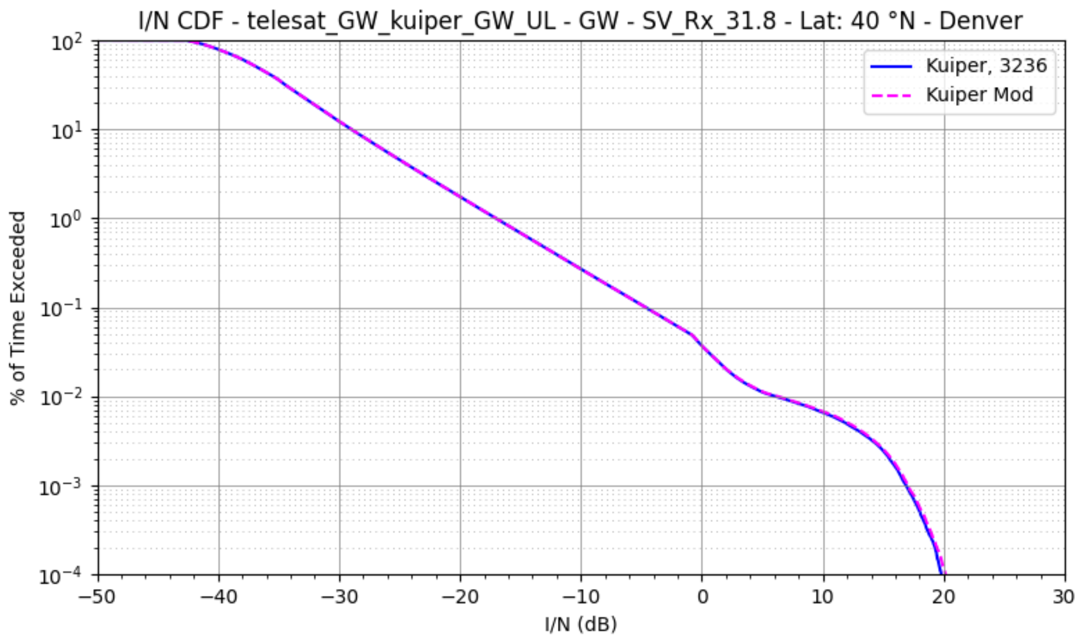


Figure A4.7: Kuiper GW Uplink into Telesat Satellite, Rx Peak Gain: 31.8 dBi

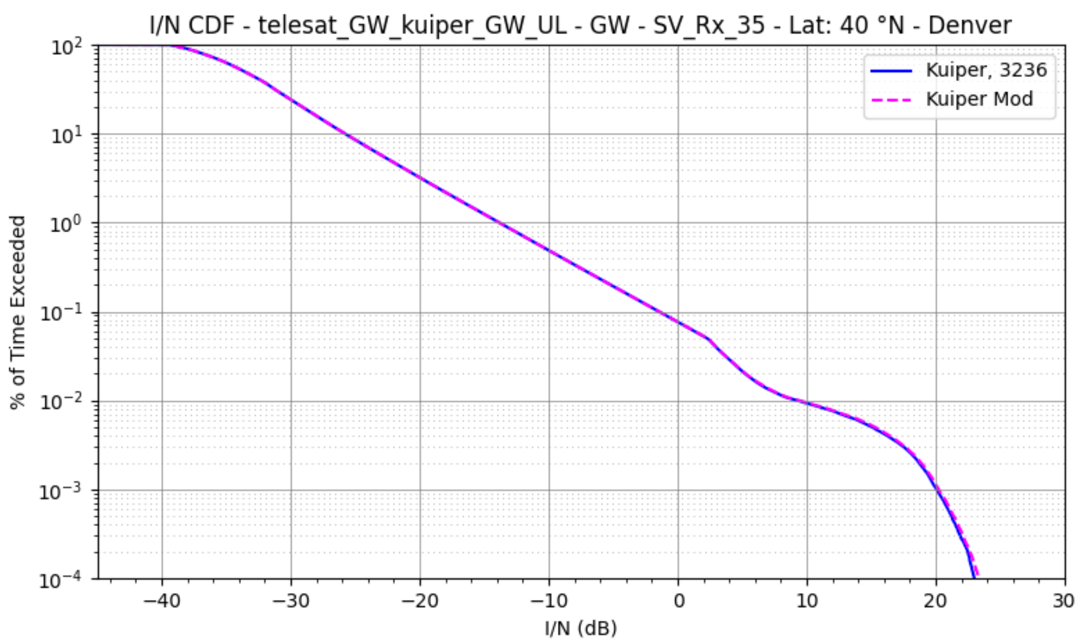


Figure A4.8: Kuiper GW Uplink into Telesat Satellite, Rx Peak Gain: 35 dBi

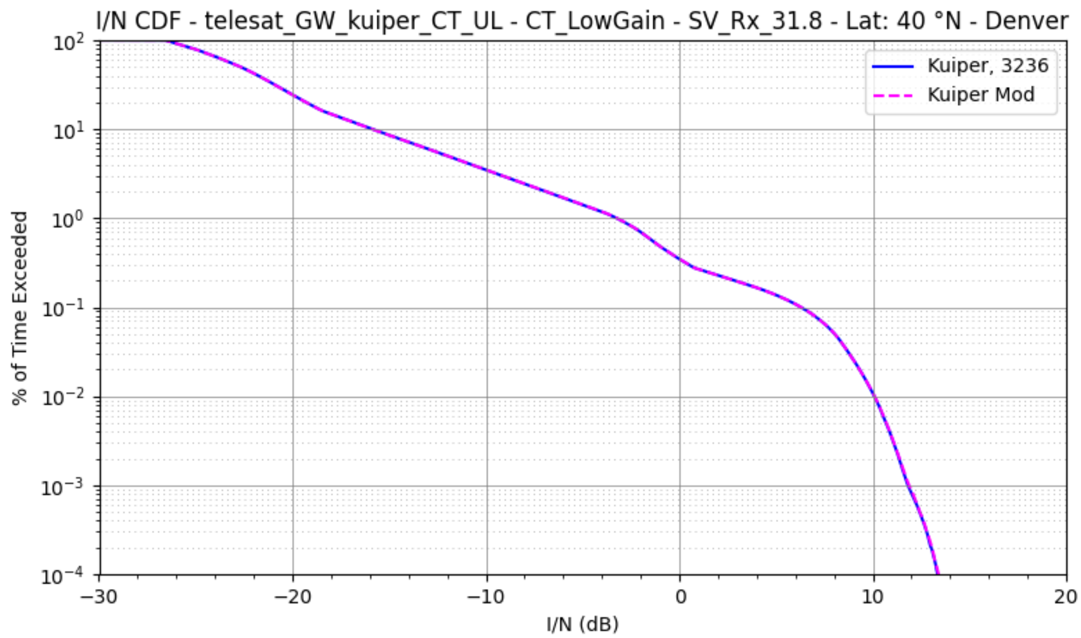


Figure A4.9: Kuiper Low Gain CT Uplink into Telesat Satellite, Rx Peak Gain: 31.8 dBi

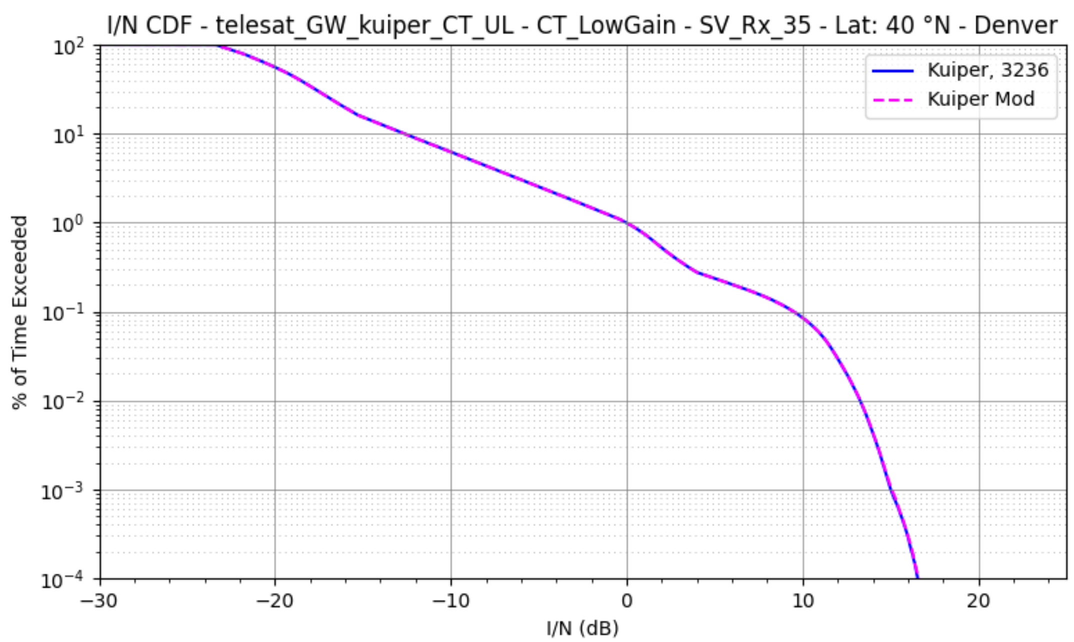


Figure A4.10: Kuiper Low Gain CT Uplink into Telesat Satellite, Rx Peak Gain: 35 dBi

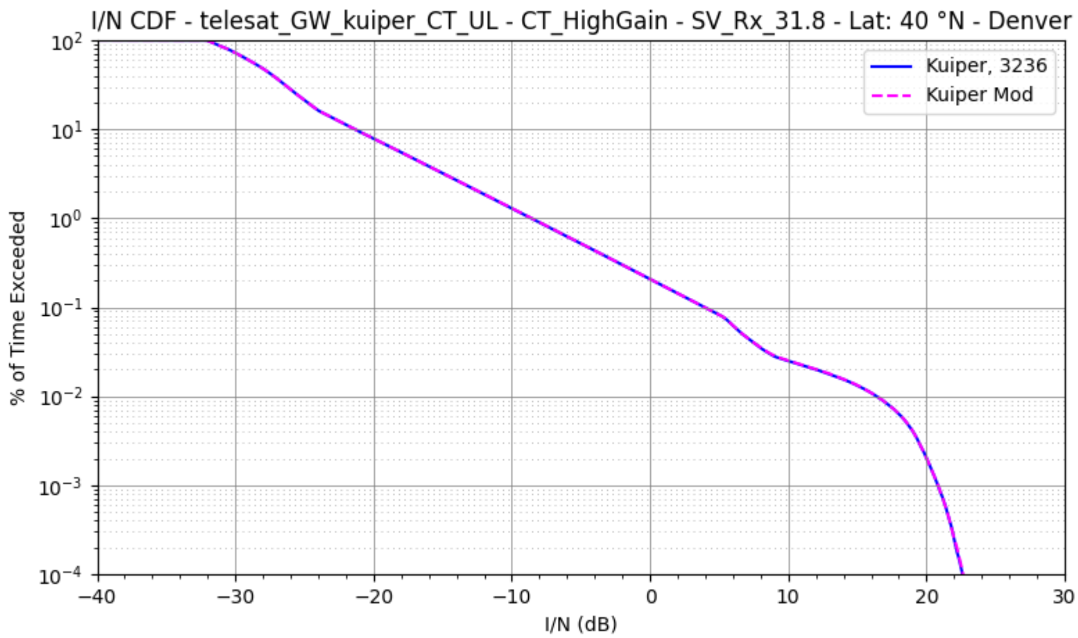


Figure A4.11: Kuiper GW Uplink into Telesat Satellite, Rx Peak Gain: 31.8 dBi

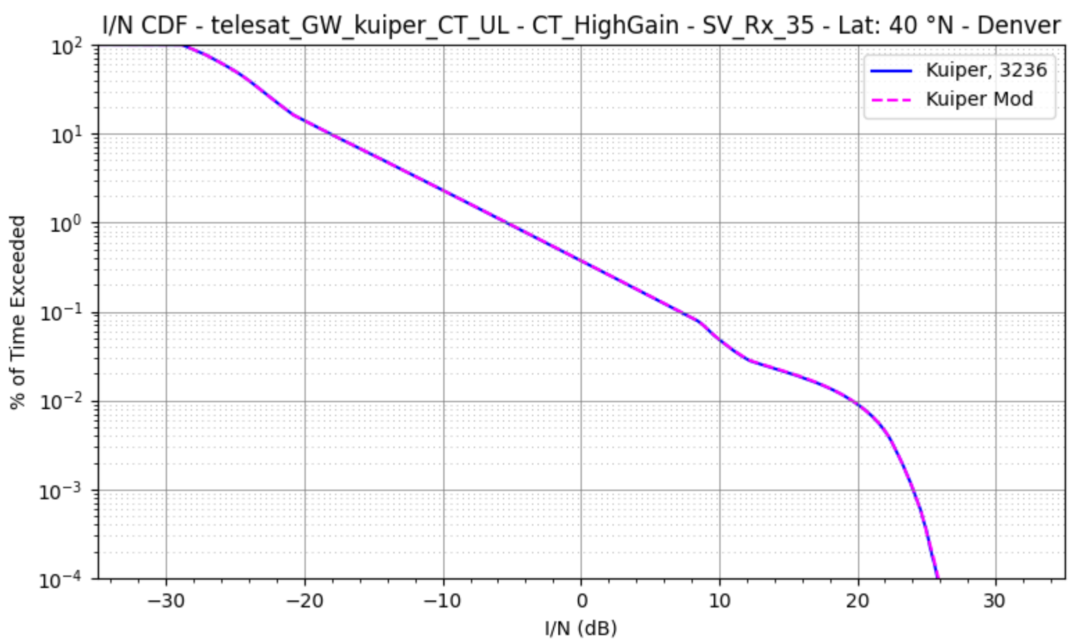


Figure A4.12: Kuiper GW Uplink into Telesat Satellite, Rx Peak Gain: 35 dBi

A5. Viasat

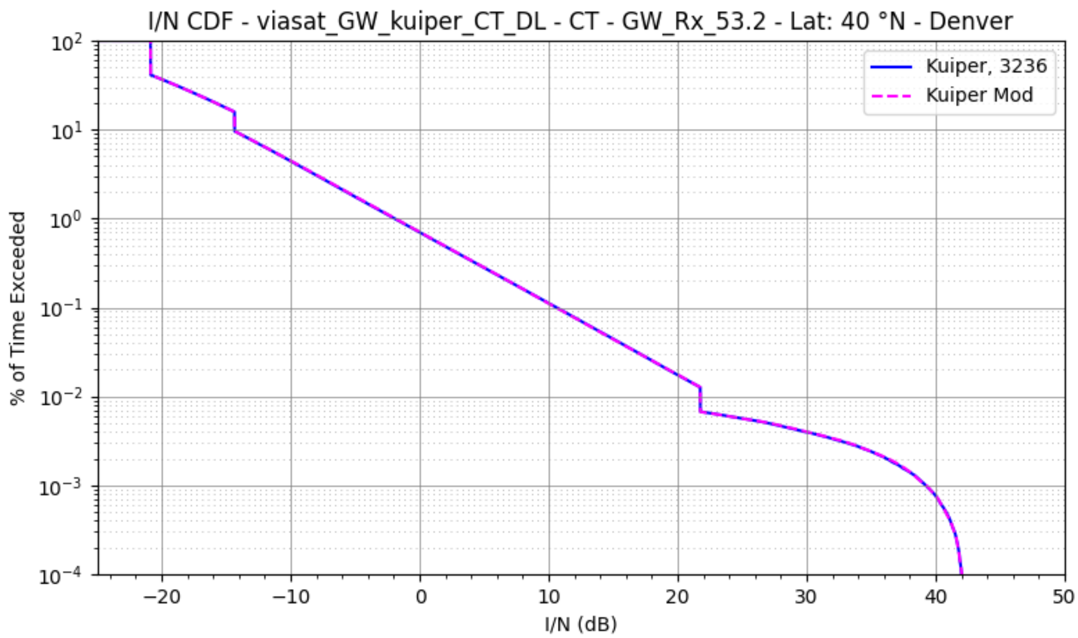


Figure A5.1: Kuiper CT Downlink Beam into Viasat Terminal, Rx Peak Gain: 53.2 dBi

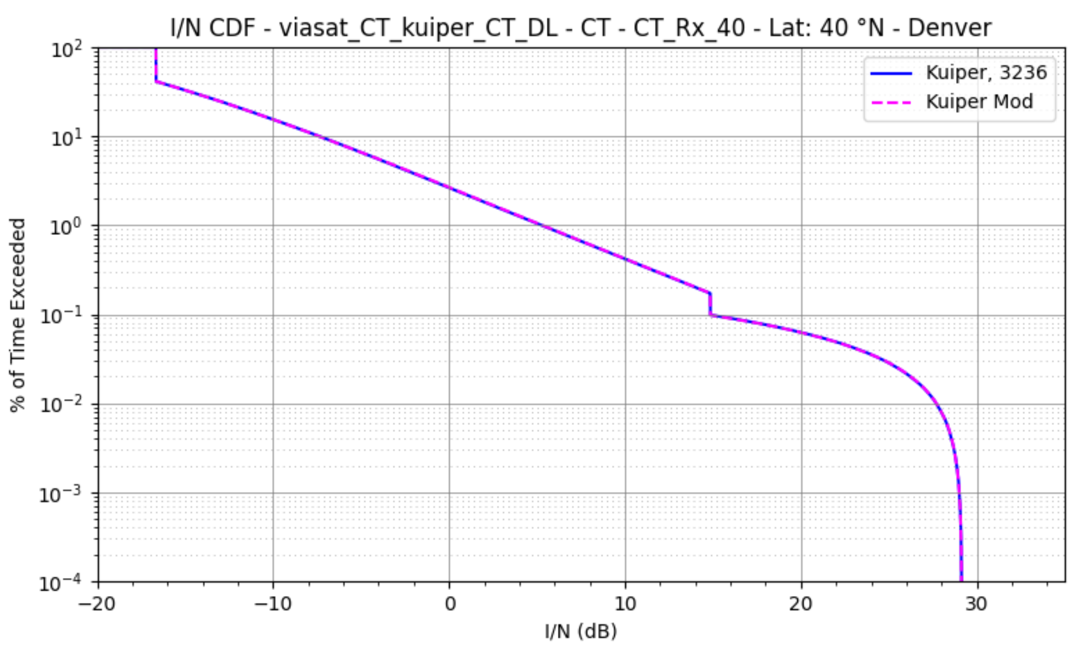
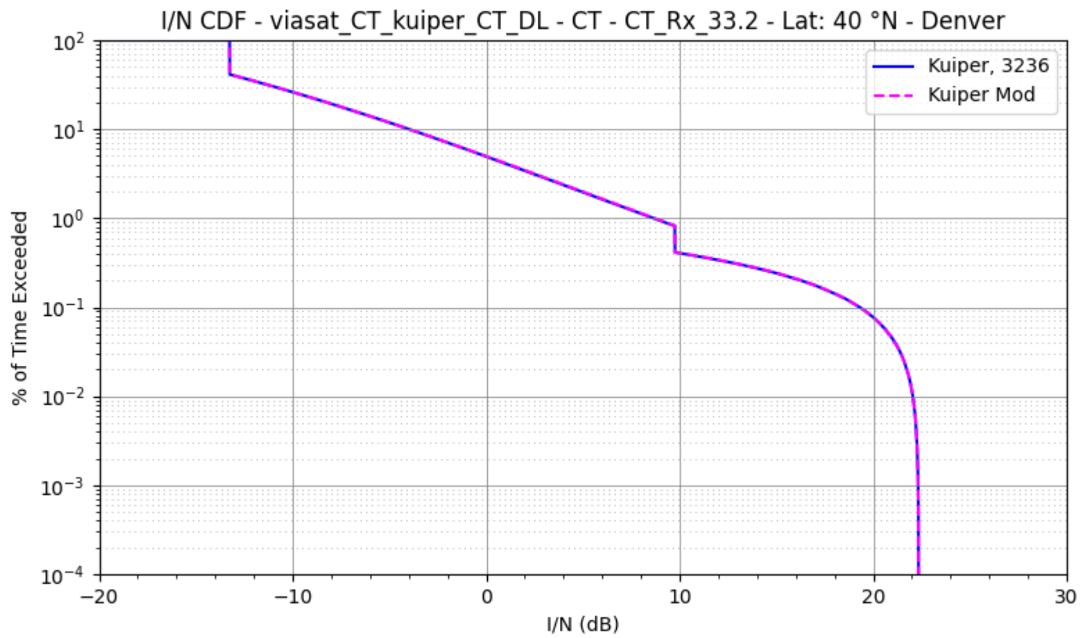
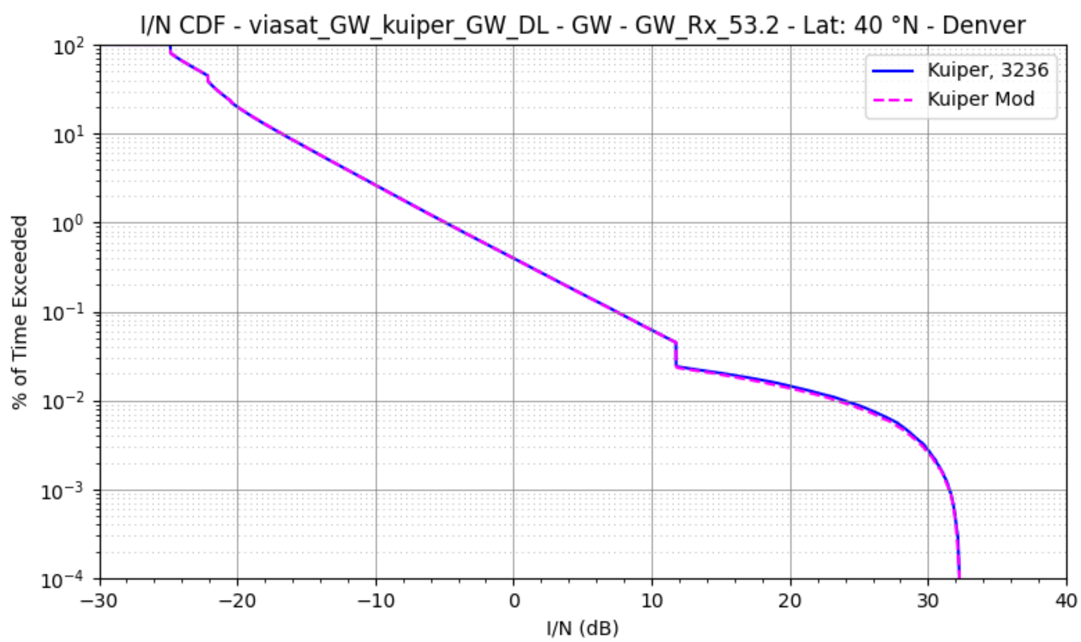


Figure A5.2: Kuiper CT Downlink Beam into Viasat Terminal, Rx Peak Gain: 40 dBi



<u>Figure A5.3</u>: Kuiper CT Downlink Beam into Viasat Terminal, Rx Peak Gain: 33.2 dBi



<u>Figure A5.4</u>: Kuiper GW Downlink Beam into Viasat Terminal, Rx Peak Gain: 53.2 dBi

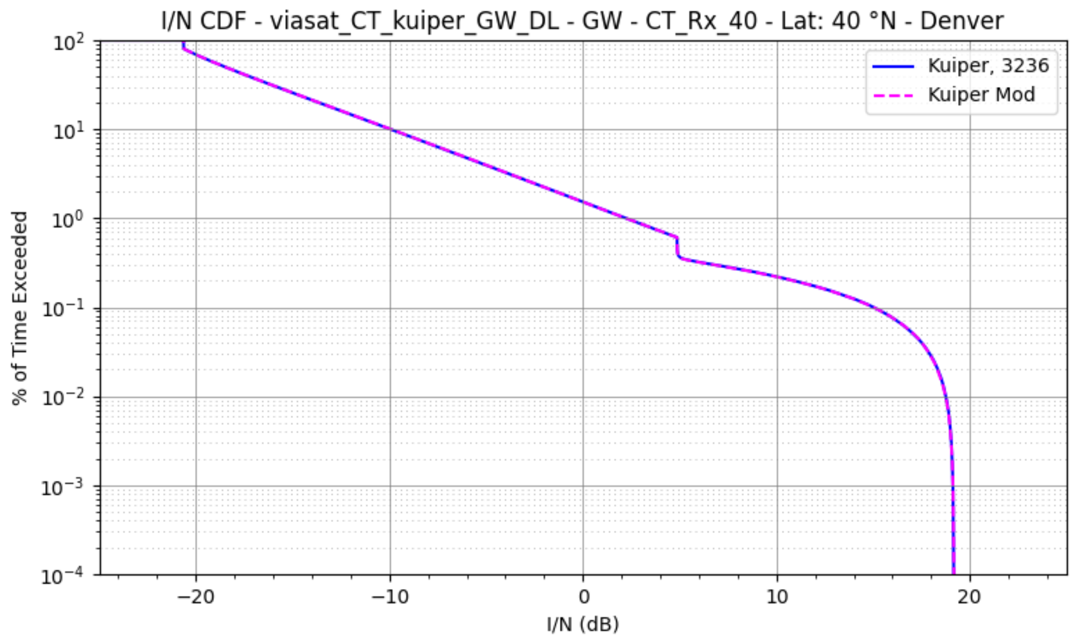


Figure A5.5: Kuiper GW Downlink Beam into Viasat Terminal, Rx Peak Gain: 40 dBi

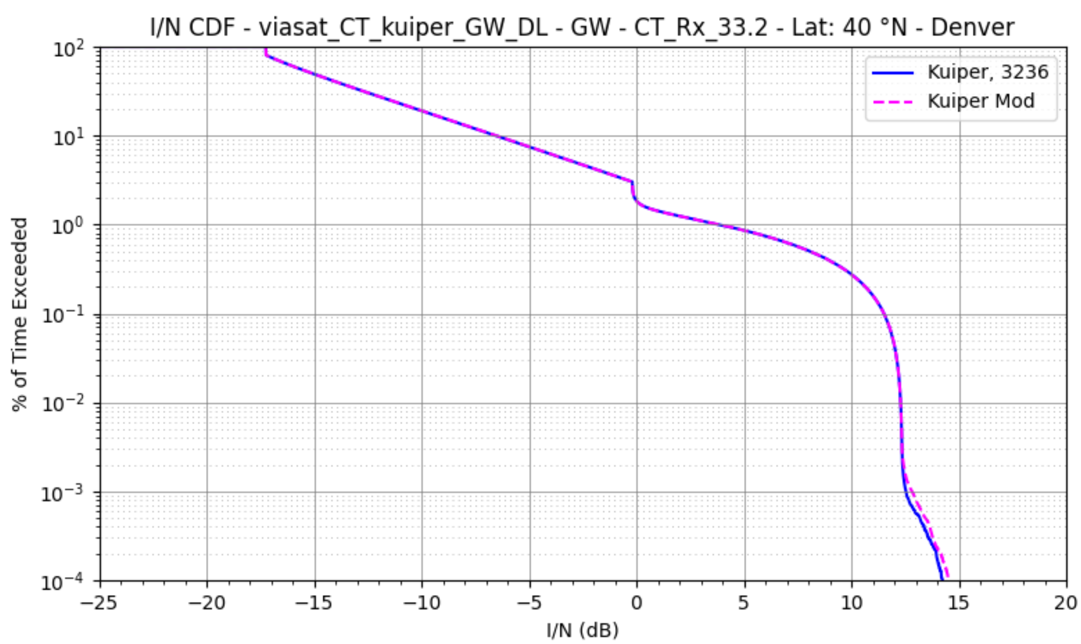


Figure A5.6: Kuiper GW Downlink Beam into Viasat Terminal, Rx Peak Gain: 33.2 dBi

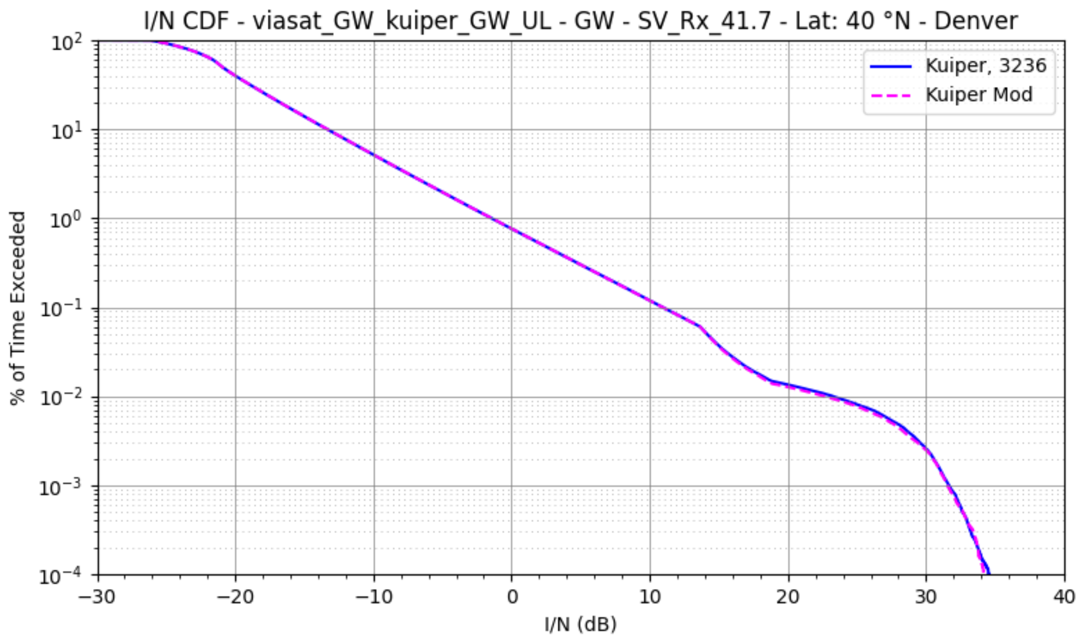


Figure A5.7: Kuiper GW Uplink into Viasat Satellite, Rx Peak Gain: 41.7 dBi

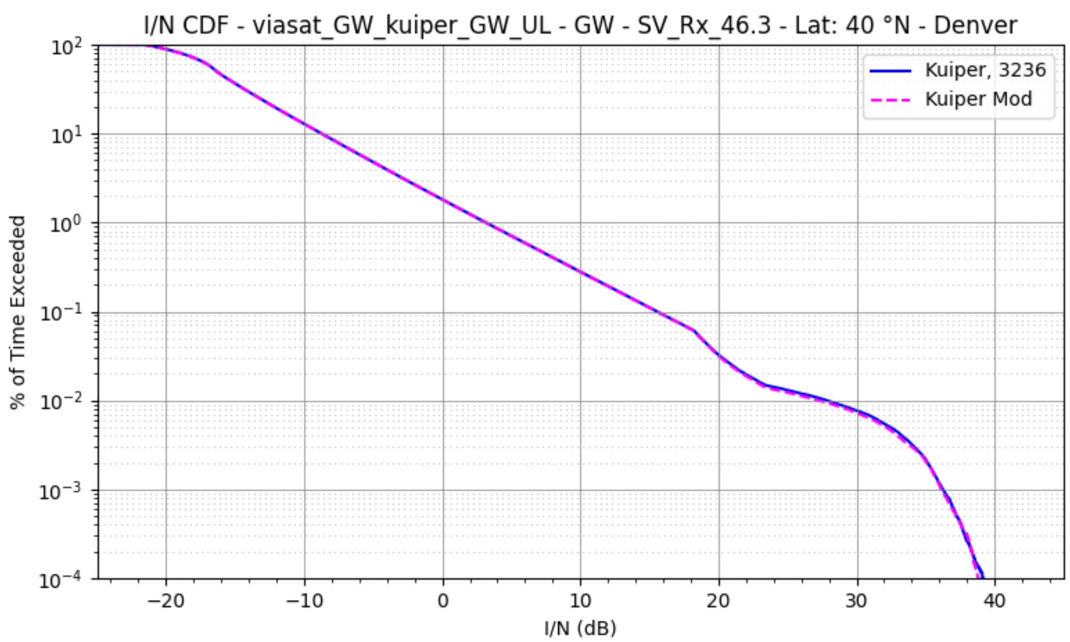


Figure A5.8: Kuiper GW Uplink into Viasat Satellite, Rx Peak Gain: 46.3 dBi

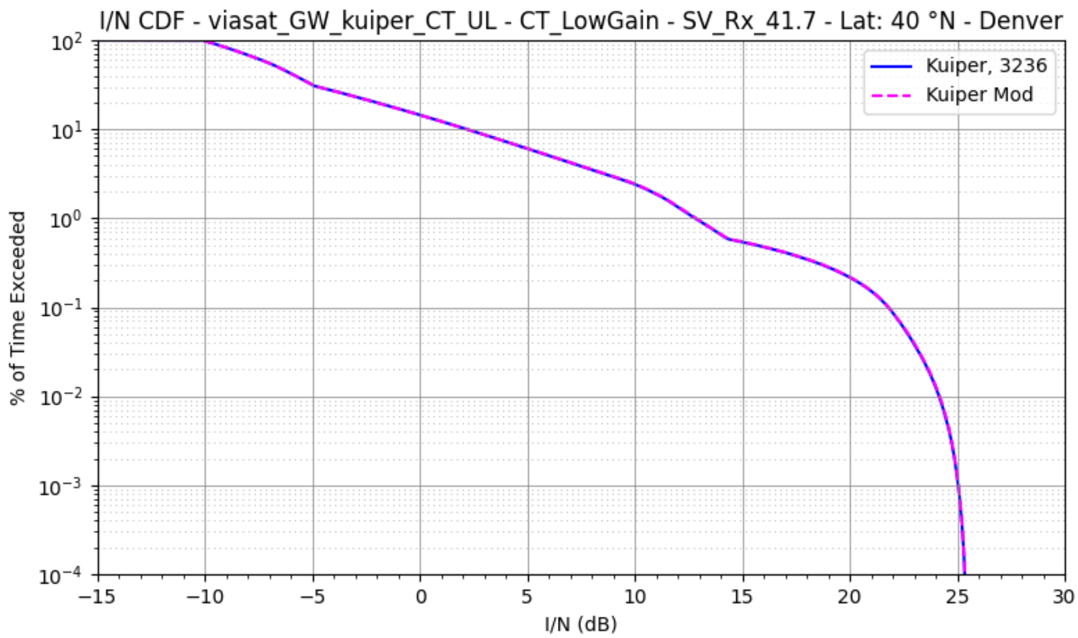


Figure A5.9: Kuiper Low Gain CT Uplink into Viasat Satellite, Rx Peak Gain: 41.7 dBi

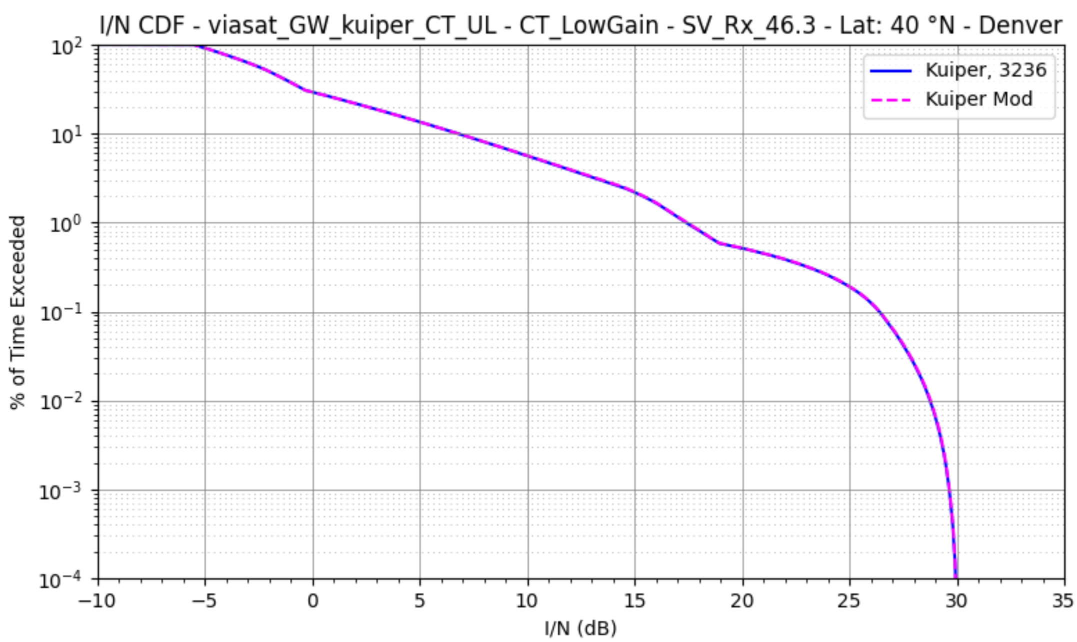


Figure A5.10: Kuiper Low Gain CT Uplink into Viasat Satellite, Rx Peak Gain: 46.3 dBi

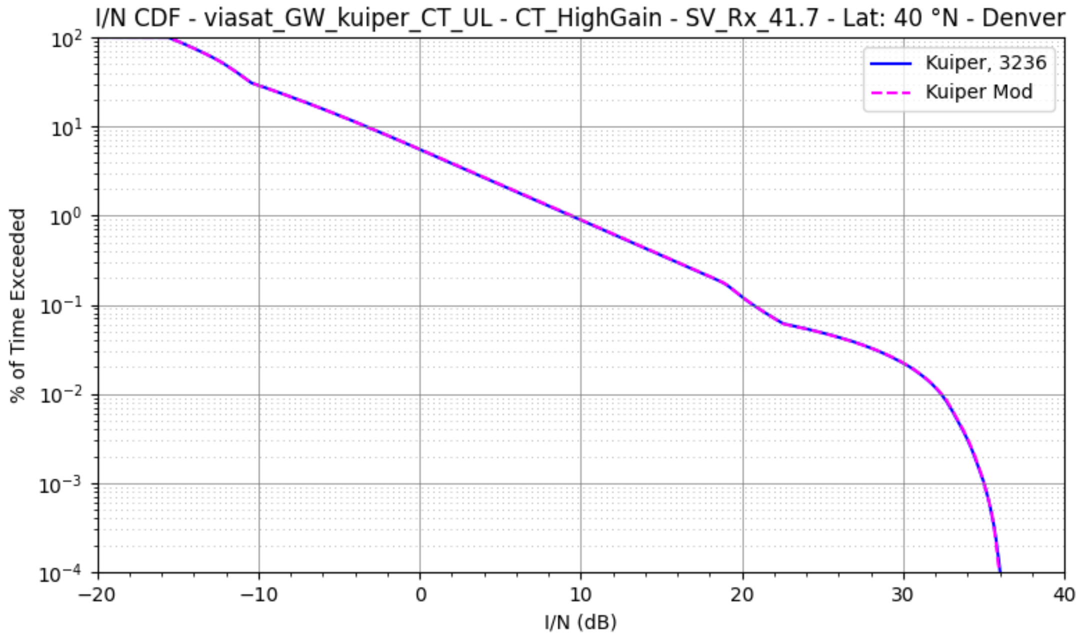


Figure A5.11: Kuiper High Gain CT Uplink into Viasat Satellite, Rx Peak Gain: 41.7 dBi

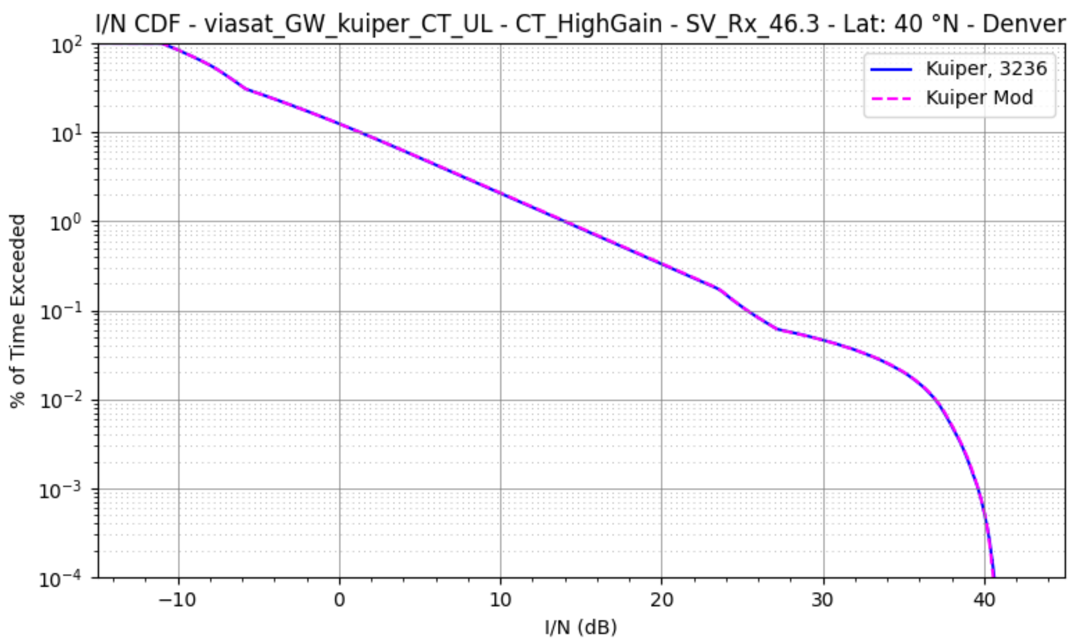


Figure A5.12: Kuiper High Gain CT Uplink into Viasat Satellite, Rx Peak Gain: 46.3 dBi