Astra Space Platform Services LLC

Technical Narrative

I. Introduction

In accordance with the FCC's Part 25 Rules, this Technical Narrative documents pertinent information of Astra's Constellation, including, but not limited to, Astra's planned constellation orbital configuration, facilities, operations, services, interference compliance, and orbital debris mitigation plan. This information is intended to supplement the technical parameters specified in Astra's Schedule S.

II. Astra's Constellation (25.114(a)(2), 25.114(c)(6)(i,ii), 25.114(c)(7), 25.114(c)(10), 25.114(d)(14)(iv)(A)(2))

Astra's Constellation consists of 13,620 identical (25.114(a)(2)) satellites that will be deployed in three phases, distributed at equatorial, mid-inclination and sun-synchronous (SSO) Low Earth Orbit (LEO) altitudes. A breakdown of the orbital parameters, plane count, satellites (or space stations) per plane, satellites per orbital shell and total satellites per phase is provided in Table 1.

Table 1. Astra Constellation Phases

Phase	Shell	Altitude (km)	Inclination (deg.)	Number of Planes	Satellites per Plane	Satellites per Shell	Total Satellites per Phase
Phase 1.0	Equatorial	700	0	1	40	40	40
Phase 2.0	Sun-Sync Med-Inclined	690 700	98 55	14 56	36 32	504 1792	2,296
Phase 3.0	Sun-Sync Low-inclined Med-inclined	380 390 400	97 30 55	20 51 61	112 96 68	2,240 4,896 4,148	11,284

Coverage maps for the three phases are provided in Figure 1.

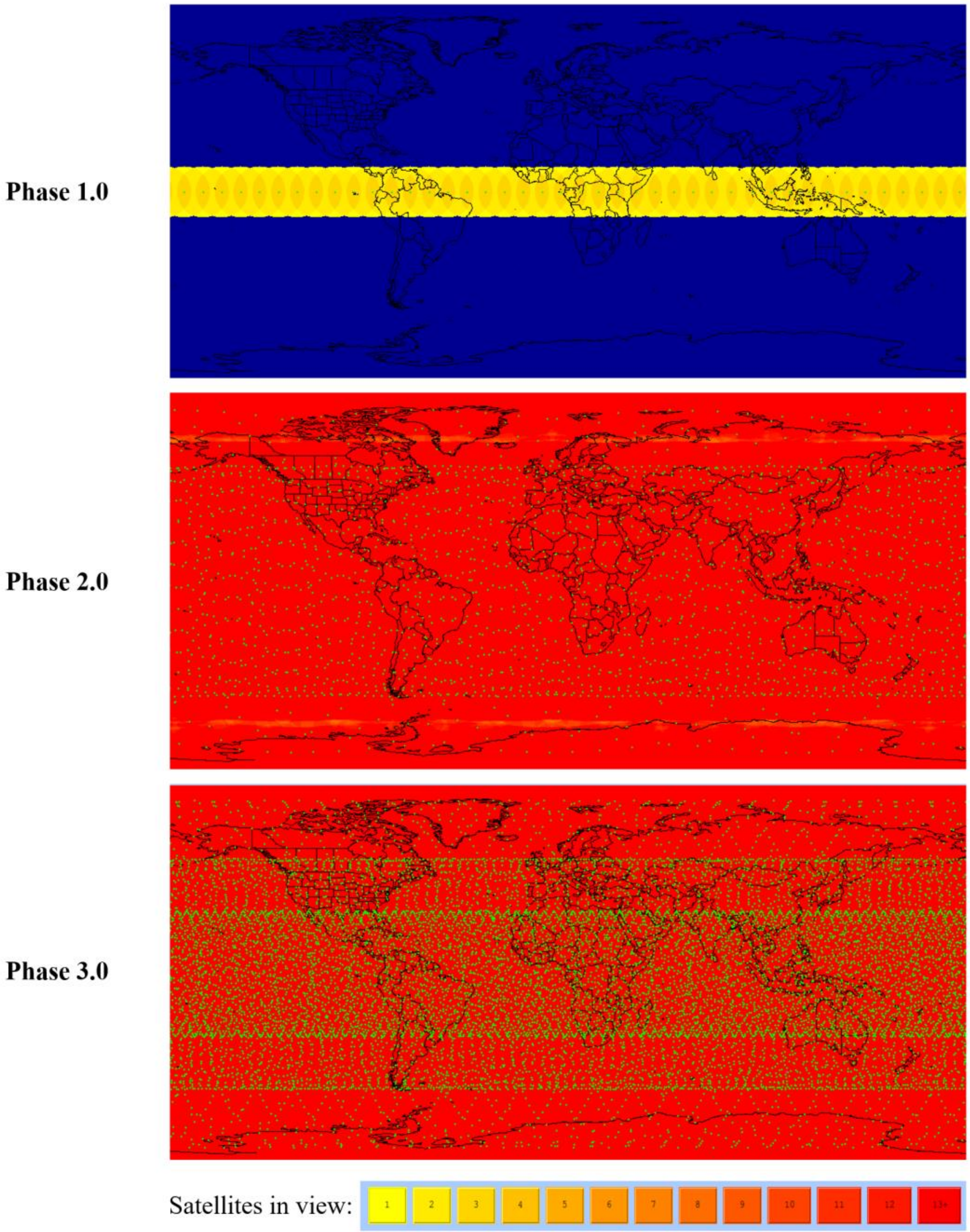


Figure 1. Illustrative coverage maps for each phase of Astra's Constellation[1]

Each phase of Astra's Constellation addresses a strategic coverage goal and supports Astra's iterative approach to product development. To elaborate, as is required by 25.114(c)(7): Phase 1.0 will

[1] Note that these illustrative coverage maps do not reflect the impact of GEO arc avoidance. Astra will operate its Constellation in such a way as to avoid interference with GEO satellite systems.

serve as a minimum viable product, providing continuous broadband service for limited equatorial latitudes with a relatively small number of satellites. This Phase is designed to allow Astra to introduce continuous service in a test market as soon as possible, learn from initial operations and customer feedback, and iteratively improve all elements of the service to better meet customer needs.

Those improvements will carry forward at a larger scale in Phase 2.0, which is designed to provide continuous broadband service at all latitudes. A mix of mid-inclination and sun-synchronous (SSO) orbital planes is used to concentrate coverage in mid latitudes, aligned with the geographic distribution of users. The inclusion of SSO orbital planes provides both (1) polar coverage, and (2) augmentation of service capacity at fixed local times of day in mid latitudes. The total number of satellites in Phase 2.0 is a fraction of the total Constellation, allowing Astra to deliver global service sooner, learn from operations and customer feedback, and continue iteratively improving the service.

Finally, Phase 3.0 will carry forward learnings from Phase 1.0 and 2.0 and scale up capacity for users worldwide. Phase 3.0 will utilize a mix of low-inclination, mid-inclination, and SSO orbital planes to more efficiently match coverage to the distribution of users across latitudes. In contrast to Phase 1.0 and 2.0, Phase 3.0 will leverage a lower operational altitude of 400 km in order to both (1) more efficiently utilize spectrum resources to deliver service to users at scale, and (2) support Astra's orbital debris mitigation strategy by accelerating de-orbit of satellites at end-of-life.

When designing its Constellation, Astra prioritized space safety and worked diligently to mitigate potential on-orbit collision risk with planned and/or operational space stations, including the International Space Station (ISS), the planes of its own system and other satellite constellations operating at comparable altitudes (25.114(d)(14)(iv)(A)(2)). To protect the ISS, Astra has ensured a minimum orbital separation of at least 20 km between Astra's satellites and the ISS. In order to avoid collision risks within its own system, Astra has also separated the orbital shells of its Constellation by at least 10 km.

With regards to other satellite systems operating in LEO, Astra has selected operational altitudes that are separated from other LEO systems to minimize collision risk. Table 2 provides a summary of the minimum separation distance between Astra's proposed orbital altitudes and the orbital altitudes of other notable LEO systems. The smallest altitude separation between Astra's Constellation and other systems is 6.8 km, which exceeds the minimum plane separation within the SpaceX Gen 2 Constellation (6.1 km). All other systems are separated from Astra's Constellation by at least 40 km in altitude.

Table 2. Operational and Planned Orbital Altitudes of and Separation Distance Between Other Operators and Astra's Constellation

Operator	**Constellation**	**Orbital altitudes (km)**	**Minimum separation distance from Astra's orbital altitudes**
SpaceX	SpaceX Gen 1	540	6.8 km
		550	
		560	
		570	
	SpaceX Gen 2	328.3	
		334.4	
		345.6	
		360	
		373.2	
		498.8	
		604	
		614	
Kepler	Kepler	600 ± 50	40 km
Amazon	Kuiper	590	60 km
		610	
		630	
O3b	O3b	507	107 km
		8062	
Telesat	Telesat Phase 0	1000	300 km
		1248	
	Telesat Phase 1	1015	
		1325	
	Telesat Phase 2	1015	
		1325	
OneWeb	OneWeb Gen 1	1200	500 km
	OneWeb Gen 2	1200	
ViaSat	ViaSat LEO	1300	600 km

In addition to Astra's efforts to separate its Constellation from existing and planned constellations in neighboring orbits, Astra has also selected operating altitude ranges that will minimize collision risks with existing passive debris. More than 80% of Astra's proposed satellites will operate at a low orbital altitude range of 380 - 400 km, which contains a relatively low spatial density of existing debris as seen in Figure 2 below.

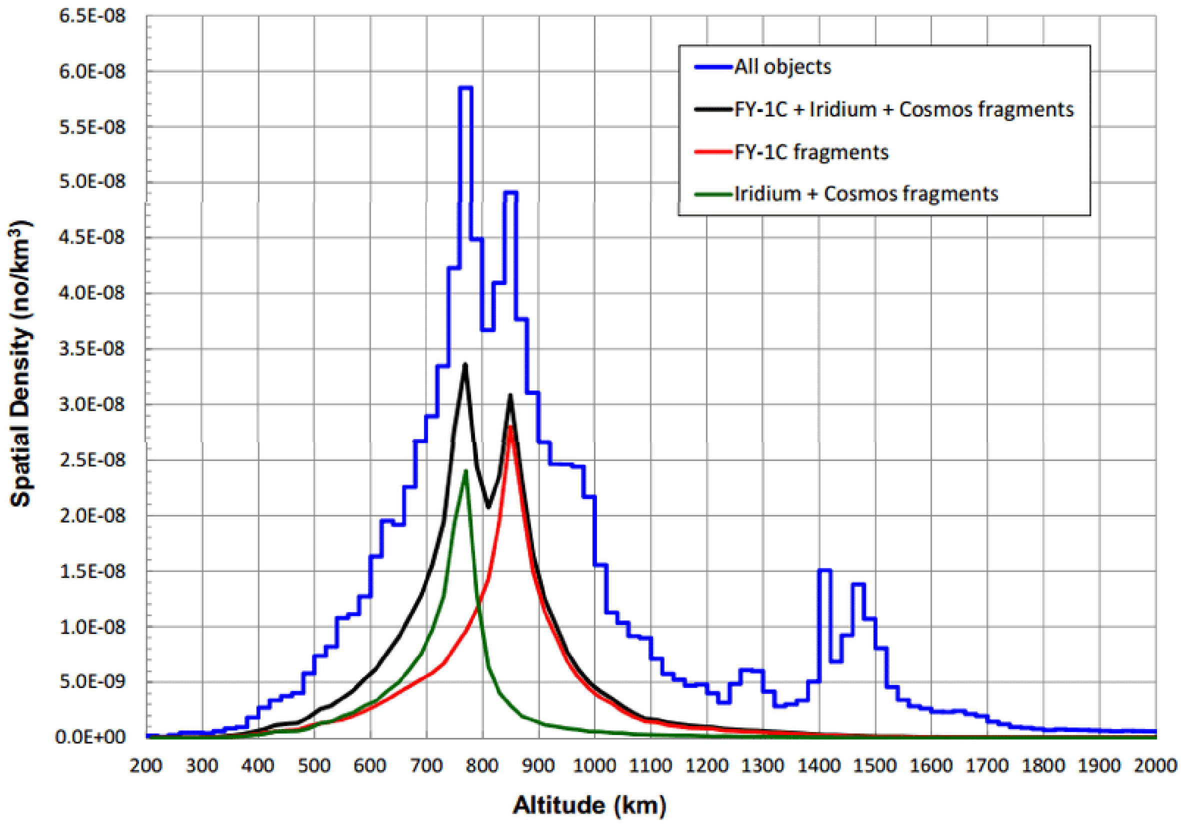


Figure 2. Spatial Density of space objects as a function of Altitude as of January 2013[2]

A. Astra's Constellation - Space Segment

Each of the Astra space stations will have an estimated operational lifetime of five years (25.114(c)(10)) and consist of state of the art propulsion and communications technologies. These technologies will ensure that Astra satellites will be able to maneuver upon command and respond to

[2] Diagram adapted from Brigo, T.P., C.C. Celestino, and R.V. Moraes. "A brief scenario about the 'space pollution' around the Earth." Journal of Physics: Conference Series. Vol. 465. No. 1. IOP Publishing, 2013.

conjunction alerts and collision risks on orbit, as appropriate. The propulsion subsystem provides impulse for spacecraft maneuvering during its operational lifetime and is based on Hall Effect thruster technology. The propulsion subsystem consists of a single Hall Effect thruster, a single power processing unit (PPU) and a propellant storage and management system, which both stores propellant and delivers regulated mass flow to the thruster where it is ionized and accelerated to produce thrust. These technologies, along with Global Navigation Satellite System (GNSS) capability to provide exact location, will equip the Astra satellites with the means for controlled and deterministic orbital maneuvers and precision in orbital positioning.

The communications subsystem will consist of an on-board processed, regenerative payload, including a novel phased array with an effective aperture of 0.2 m, as well as two gimballed parabolic dishes of the same effective aperture area to serve as backup feederlink support. The phased array antenna will be capable of producing shapeable and steerable beams to users and gateways at the same time. The gateway beams of the phased array will be carefully shaped to match the beam patterns of the gimballed parabolic backup gateway antennas, as such distinctions in beam patterns and parameters have not been made in this showing or in our Schedule S. Astra notes that two gimballed antennas are required for handover purposes.

B. Astra's Constellation - Ground Segment

The Ground Segment of Astra's Constellation consists of user terminals, located at customer premises, and gateway antennas, connected via fiber to the Internet. Both user terminals and gateways will operate over the same V-band frequencies, which will be tabulated in subsequent sections. Given that V-band is susceptible to significant fade, uplink adaptive power control will be implemented to facilitate transmission while minimizing interference (25.204(e)). Adaptive Coding and Modulation (ACM) will also be used to support a wide span of modulation and coding schemes, ranging from BPSK to 32APSK during operations.

1. User Terminals

User terminals will consist of parabolic dish and phased array architectures that will operate down to a minimum elevation angle of 20 degrees, thus complying with 25.205(a), which states that earth stations will not transmit at an elevation angle less than 5 degrees measured from the horizontal plane to the direction of maximum radiation. It is important to note, however, that while user terminals operate with a minimum elevation of 20 degrees, nominally, user terminals will typically operate at higher angles. This in turn will aid in minimizing path loss, fade, and increasing throughput.

2. Gateway Antennas

On the other end of Astra's communication system is the gateway, which will consist of 1 m parabolic dishes that operate down to a minimum elevation angle of 15 degrees, similarly complying with 25.205(a). Astra will route its TT&C traffic through these 1 m parabolic gateway antennas.

Astra is familiar with 25.202(a)(1)(ii), 25.202(j) and 25.136 of the Commission's Rules, which define requirements for Earth Stations (ES) in bands including 37.5 - 40.0 GHz, 47.2 - 48.2 GHz and 50.4 - 51.4 GHz. While Astra is not currently applying for individually licensed earth stations in these bands at this time, it has designed its system with geographic site location, protection zone, and coordination with the Upper Microwave Flexible Use Service (UMFUS) in mind (25.136(c)(1), 25.136(d) and 25.136(e)) as well as the requirements stated in 25.202.

C. Astra's Constellation - Facilities, Operations and Services (25.114(d)(1))

This section of the Technical Narrative describes the systems' facilities, operations, services and how the uplink frequencies are connected to downlink bands for the Astra Constellation.

1. Facilities

In accordance with 25.272(a), Astra will establish a satellite network control center in the U.S. that will be responsible for monitoring the space-to-Earth and Earth-to-space transmissions in the system (25.272(a)(1)). The control center will also coordinate transmissions with those of other systems to prevent harmful interference, or in the event of harmful interference, identify the source of the interference and correct the problem promptly (25.272 (a)(2)). All Astra facilities will be properly secured and maintained against unauthorized access, ensuring the security of all satellite commands, as required in 25.271(a) and 25.271(d). To this end, Astra will leverage its years of experience operating secure ITAR-controlled facilities for launch vehicle development, production, and operations.

2. Operations

a) Launch

Astra plans to launch satellites for its Constellation using its own in-house launch service of its affiliates, allowing for a more rapid, flexible, and cost-effective deployment of the Constellation. While this is the baseline plan, Astra is also willing and able to utilize third party launch providers in part or in whole for Constellation deployment. Astra's launch vehicles are currently planned to be capable of deploying at least two Astra satellites per launch, and are planned to reach a daily launch cadence. Together with third party launch options, Astra will comply with 25.164(b) by deploying and operating 50 percent of the Constellation no later than 6 years after the grant of the authorization (25.164(b)(1)), and the remainder no later than 9 years after the grant of the authorization (25.164(b)(2)).

All Astra satellites will be larger than 10 cm in their smallest dimension, and also trackable per 25.114(d)(14)(v). To comply with 25.114(d)(14)(v)(A), Astra's satellites will have onboard GNSS with a position error tolerance of under 2.5 m, supporting active tracking of all satellites. At appropriate intervals, Astra will also propagate the orbital trajectories of all its satellites to ensure there are no conjunctions with other satellites or the International Space Station, and will plan maneuvers accordingly.

b) In-orbit Operations

Astra is committed to prioritizing safe, cooperative operations of its space vehicles -- a reflection of the deep heritage among Astra's founders for innovative work contributing to the development of space and scientific discovery at NASA. Astra intends to collaborate with other space operators, the U.S.

Space Force and other relevant space situational awareness platforms to maximize the physical on-orbit safety of its Constellation and the space environment generally.

Prior to deployment, Astra will register with the U.S. Space Force's 18th Space Control Squadron ("18th SPCS") or appropriate successor entity (25.114(d)(v)(B)), and share information regarding initial spacecraft deployment, ephemeris and planned maneuver information, which it will continue to update during the course of its mission (25.114(d)(v)(C). Additionally, in accordance with 25.114(d)(iv)(A)(5), Astra asserts that upon receipt of a space situational awareness conjunction warning, it will review and take all possible steps to assess collision risk and will mitigate collision risks if necessary.

In order to maximize transparency, Astra will make publicly available its satellite position ephemeris information by hosting two line element (TLE) sets online to ensure awareness beyond the community of other space operators. Astra is also aware of the impact of satellite constellations on optical and radio astronomy and will work hand-in-hand with the astronomical and scientific community to ensure that impact to scientific discovery is not hindered by the deployment and operation of its Constellation.

Astra intends to collaborate with satellite operators of incumbent and future systems to share relevant information. Astra will engage the operator of any active spacecraft involved in conjunction warnings, sharing ephemeris data and other appropriate operational information to assess the risk of collision and evaluate appropriate action, including modifying the altitude and/or operations of Astra satellites to maintain safety. Astra will maintain inclination to within +/- 0.1 degrees. After Astra has completed Critical Design Review (CDR), it will furnish the accuracies within which orbital parameters, including apogee, perigee, and right ascension of the ascending node (RAAN) will be maintained to align with the anticipated evolution over time of the orbit (25.114(d)(14)(iv)(A)(4)).

Astra's Constellation will not incorporate in-orbit spares, but will utilize a responsive replenishment approach, replacing satellites in the network with on-ground spares within days, taking advantage of Astra's rapid launch capability. Astra asserts that its responsive replenishment approach is superior to a method of on-orbit spares given the increased risk of potential collision when operating a larger constellation than required. The deployment of Astra's on-ground spare satellites will comply with the relevant Commission's 25.113 Station construction, deployment approval and operation of spare satellite rules, and Astra notes that the spares will be identical to the space vehicles in orbit.

In accordance with 25.207 and 25.273, each active space station will also be equipped with appropriate devices (ground command, power, and timing devices) so that beams can be individually turned off or on, or transmitted in any manner that causes unacceptable interference. In addition to sharing ephemeris data, Astra will maintain a complete and accurate log of current and planned transmissions, which it is committed to providing if deemed appropriate for interference mitigation (25.273)

c) End-of-Life

At end-of-life, on-board fuel reserves will be utilized to perform controlled and targeted decommissioning and disposal maneuvers (25.114)(d)(14)(2)(i), decreasing perigee below 300 km and orienting the space station for maximum atmospheric drag such that the vehicle atmospheric re-entry time will be measured on the order of days (25.114(d)(14)(vii)(B), 25.114(d)(14)(vii)(D)(2)). To minimize risk of collision and avoid posing operational constraints to inhabitable spacecraft, Astra asserts that operational strategies will be incorporated into the deorbit maneuvers of Astra's space vehicles located above the ISS, which must transit through inhabitable spacecraft orbits during deorbit (25.114(d)(14)(iv)(A)(3)).

In accordance with 25.114(d)(vii), the quantity of fuel reserved, known as the end-of-life hold up propellant, will be sized once the propellant load mass and tank volume are confirmed, but is estimated to be on the order of 150 g. This estimate is based on end-of-life pressure in a 11 L tank, which carries the throughput limit of the propulsion system. Astra ensures that all stored energy sources onboard the satellite will be discharged by venting excess propellant, discharging batteries, and relieving pressure vessels after end-of-life maneuvers occur at the completion of Astra's authorized mission (25.283).

3. Services

Secure connectivity to the Internet, cloud services, and private data centers is an essential service for businesses and government entities with operations in remote locations, in the air, or at sea. Astra's Constellation will provide secure, low-latency, broadband connectivity services to enterprise, government, and institutional users in the United States and around the globe. Astra's offerings will include up to Gigabit-per-second link speeds, under 100 ms latency, and high availability. Services will be provided through a range of channels, including partnerships with satellite connectivity distributors, partnerships with other network operators, and direct sales to end users.

4. Explanation of How Uplink Frequencies Are Connected To Downlink Frequencies

As required in 25.114(c)(7) and 25.114(c)(4)(i), the frequency bands, channel bandwidths, and polarization are provided in Table 3, and the channel center frequencies are provided in the Schedule S. For all operations, Astra will employ full frequency reuse through the use of both right-hand circular polarization (RHCP) and left-hand circular polarization (LHCP), as well as spatially independent beams (25.210). The connectivity of uplink to downlink frequencies is via a reg

Table 3. Summary of Beam Transmission Characteristics

<table>
<tr><th>Link</th><th>Start Frequency (MHz)</th><th>End Frequency (MHz)</th><th>Bandwidth per Channel</th><th>Polarization</th></tr>
<tr><td>User + Gateway Downlink (space-to-Earth)</td><td>37500
39500
40000</td><td>39500
40000
42000</td><td rowspan="2">100 MHz (User)

250 MHz (Gateway)</td><td rowspan="4">RHCP / LHCP</td></tr>
<tr><td>User + Gateway Uplink (Earth-to-space)</td><td>47200
50400</td><td>50200
51400</td></tr>
<tr><td>Telemetry (space-to-Earth)</td><td>37500</td><td>37510</td><td>2 MHz</td></tr>
<tr><td>Telecommand (Earth-to-space)</td><td>47200</td><td>47210</td><td>1 MHz</td></tr>
</table>

The telemetry and telecommand channels were designed at band edge to minimize interference into other satellite networks (25.202(g)(1) and 25.202(g)(2)) and will consist of ten individual 1 MHz channels for telecommand and five individual 2 MHz channels for telemetry.

As it pertains to 25.112(a)(3), Astra notes that its application for the use of V-band complies with the allocations of the ITU's Radio Regulations which are summarized in Table 4, and that it is filing for both Fixed Satellite Service (FSS) and Mobile Satellite Service (MSS) use.

Table 4. FCC and ITU Allocations

Start Frequency (MHz)	**End Frequency (MHz)**	**ITU RR Allocation**
37500	39500	FSS (space-to-Earth) [all Regions]
39500	40000	FSS (space-to-Earth) [all Regions] MSS (space-to-Earth) [all Regions]
40000	42000	FSS (space-to-Earth) [all Regions] MSS (space-to-Earth) [all Regions] PRIMARY in 40 - 40.5 GHz; MSS (space-to-Earth) secondary R2 only in 40.5 - 41 GHz No MSS allocation in 41 - 42 GHz
47200	50200	FSS (Earth-to-space) [all Regions]
50400	51400	FSS (Earth-to-space) [all Regions] MSS (Earth-to-space) [all Regions] secondary

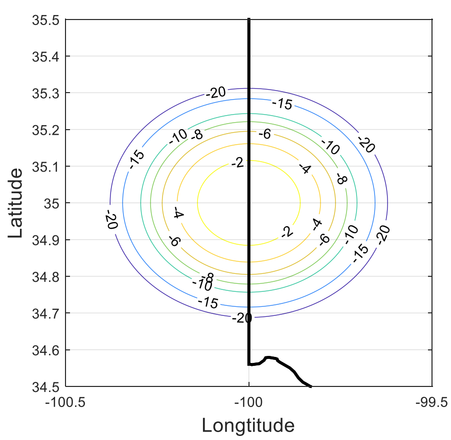
D. Astra's Predicted Space Station Antenna Gain Contours (25.114(c)(vi)(B))

As required in 25.114(c)(4)(vi)(B) of the Commission's rules, this section provides the predicted antenna gain contours for each unique orbital plane for each transmit and receive beam. Contours are plotted on an area map with the beam depicted on the surface of the earth with the space stations' peak antenna gain pointed at nadir to a latitude and longitude within the proposed service area (the edge of Texas). Furthermore, each contour is plotted at 2 dB intervals down to 10 dB below gain and at 5 dB intervals between 10 - 20 dB below the peak gain. Data for the gain contours are also embedded in the Schedule S provided in the form of GXT files.

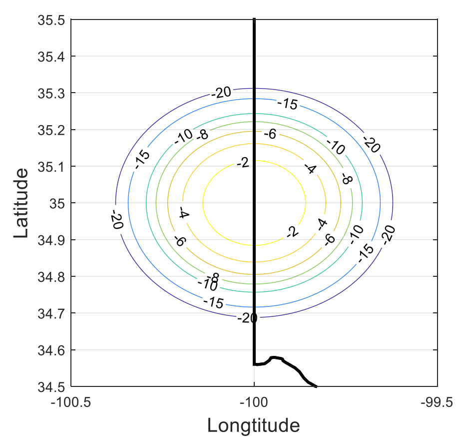
Given that the user and gateway beams are generated from the same phased array and that the backup reflector gateway dishes have the same effective aperture and therefore gain of the phased array, transmit gain contour plots of the user and gateways are the same, and the receive gain contour plots of the user and gateway beams are the same. As such only one set of contours is provided to depict the transmit beams as well as the receive beams.

These beams are considered steerable and shapeable. Contours are also provided at scan however, as soon as Critical Design Review (CDR) of the space vehicle phased array is complete, contours at the edge of the beam peak will be more accurately produced and supplied (25.114(vi)(C)).

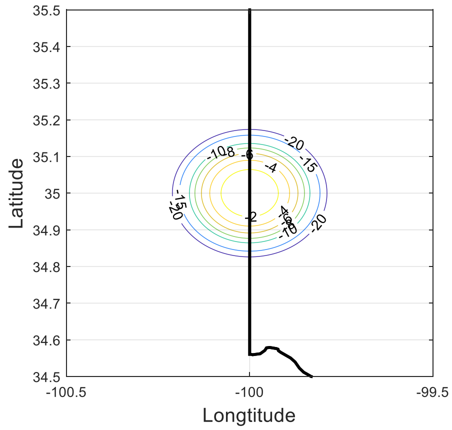
Figure 3(a-e) provides figures of the required transmit gain contours at each distinct orbital shell, pointed at nadir over the edge of Texas.



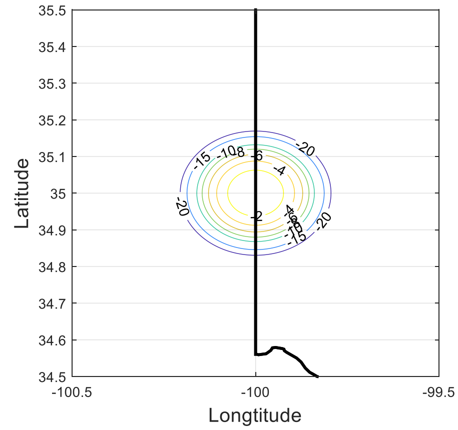
(a) 700 km (Phase 1 and 2) Tx Nadir



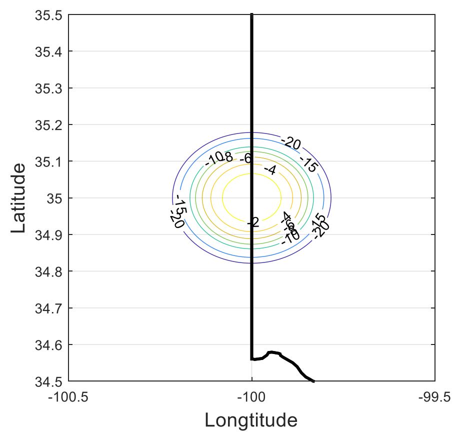
(b) 690 km (Phase 2) Tx Nadir



(c) 400 km (Phase 3) Tx Nadir



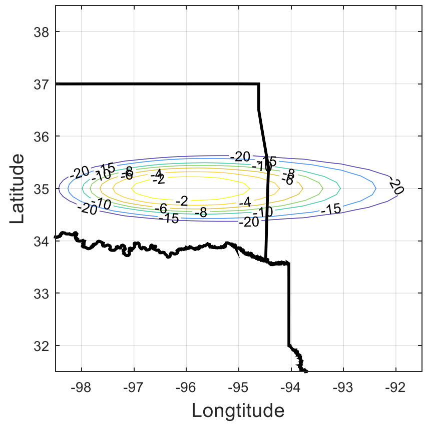
(d) 390 km (Phase 3) Tx Nadir



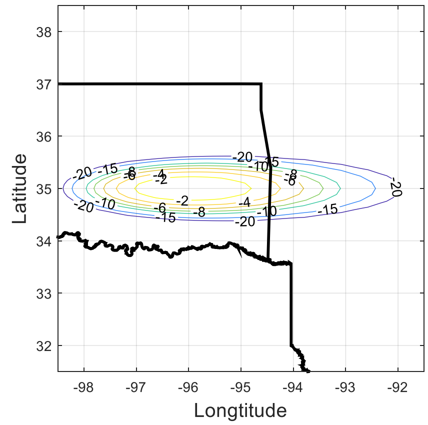
(e) 380 km (Phase 3) Tx Nadir

Figure 3(a-e): User beam Transmit Antenna Gain Contour at Nadir over the edge of Texas for (a) Phase 1 and 2: 700 km, (b) Phase 2: 690 km, (c) Phase 3: 400 km, (d) Phase 3: 390 km, and (e) Phase 3: 380 km

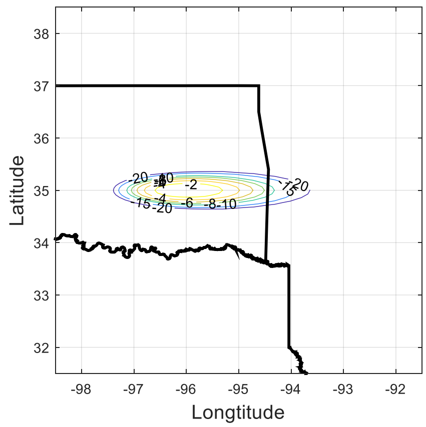
Figure 4(a-e) provides figures of the required transmit gain contours at each distinct orbital shell, at scan. In these schematics, the sub-satellite point is due West and the beam is scanned due East.



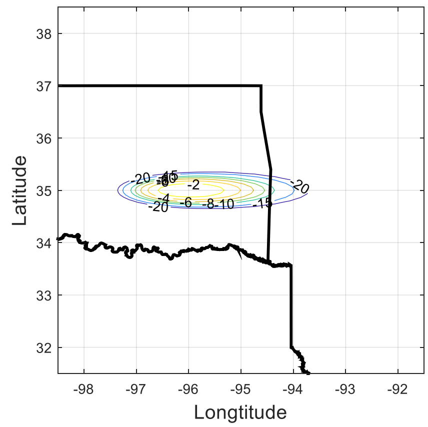
(a) 700 km (Phase 1 and 2) Tx at Scan



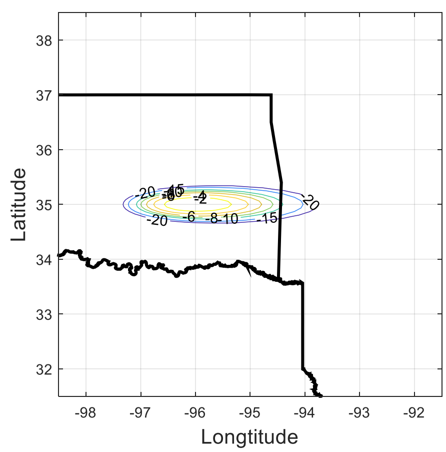
(b) 690 km (Phase 2) Tx at Scan



(c) 400 km (Phase 3) Tx at Scan



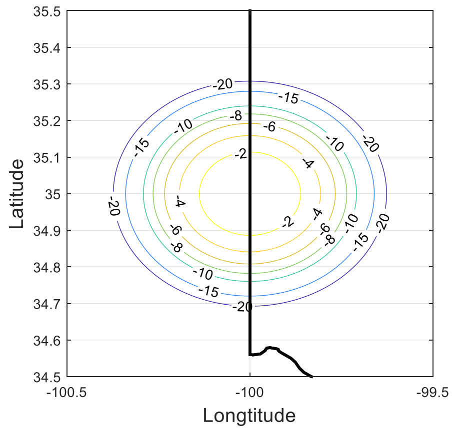
(d) 390 km (Phase 3) Tx at Scan



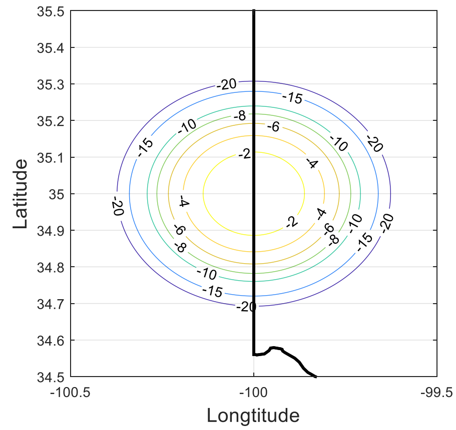
(e) 380 km (Phase 3) Tx at Scan

Figure 4(a-e): User beam Transmit Antenna Gain Contour at scan for (a) Phase 1 and 2: 700 km, (b) Phase 2: 690 km, (c) Phase 3: 400 km, (d) Phase 3: 390 km, and (e) Phase 3: 380 km

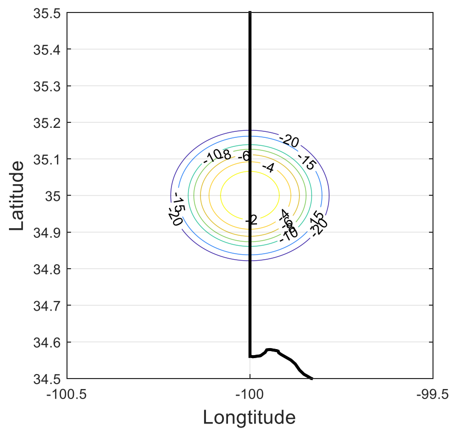
Figure 5(a-e) provides figures of the required receive gain contours at each distinct orbital shell, pointed at nadir over the edge of Texas.



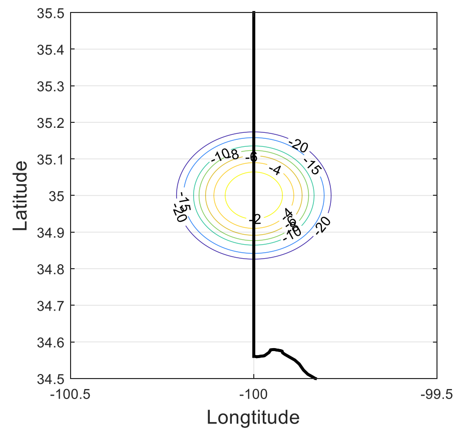
(a) 700 km (Phase 1 and 2) Rx at Nadir



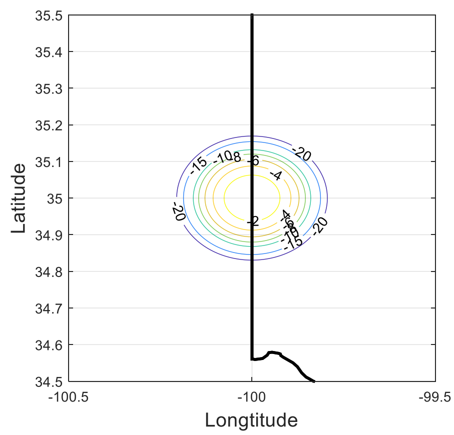
(b) 690 km (Phase 2) Rx at Nadir



(c) 400 km (Phase 3) Rx at Nadir



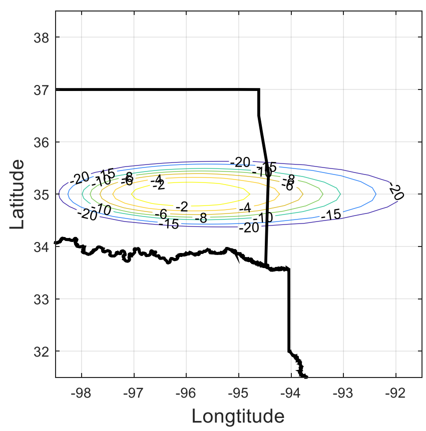
(d) 390 km (Phase 3) Rx at Nadir



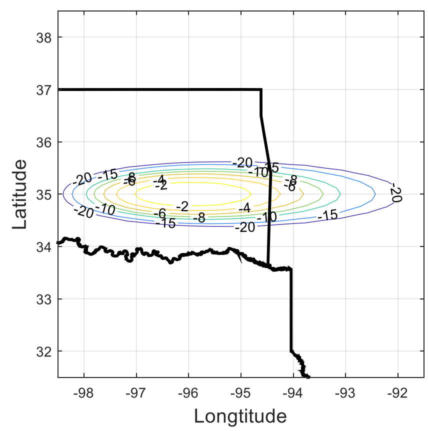
(e) 380 km (Phase 3) Rx at Nadir

Figure 5(a-e): User beam Receive Antenna Gain Contour at Nadir over the edge of Texas for (a) Phase 1 and 2: 700 km, (b) Phase 2: 690 km, (c) Phase 3: 400 km, (d) Phase 3: 390 km, and (e) Phase 3: 380 km

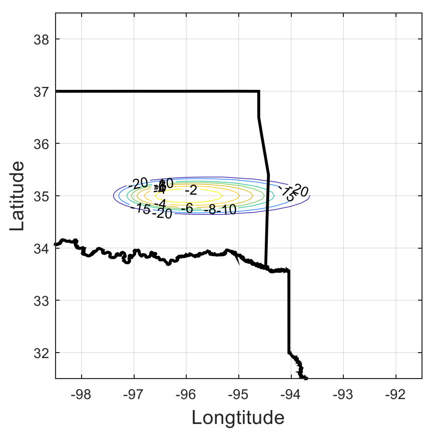
Lastly, Figure 6(a-e) provides figures of the required receive gain contours at each distinct orbital shell, pointed at scan.



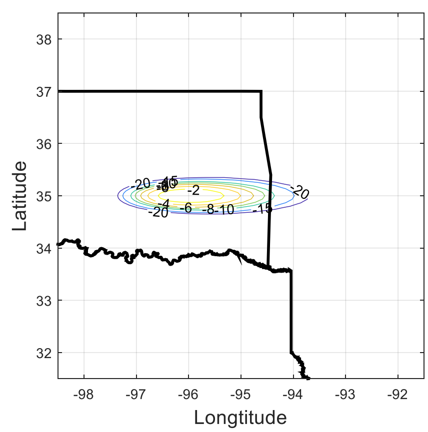
(a) 700 km (Phase 1 and 2) Rx at scan



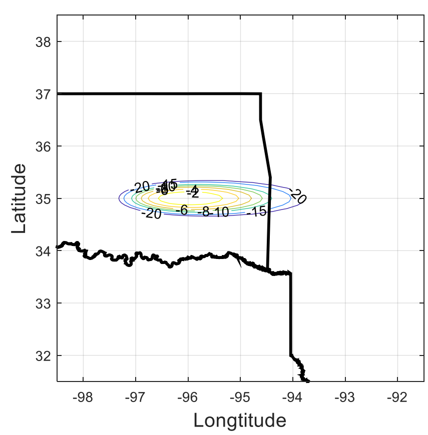
(b) 690 km (Phase 2) Rx at scan



(c) 400 km (Phase 3) Rx at scan



(d) 390 km (Phase 3) Rx at scan



(e) 380 km (Phase 3) Rx at scan

Figure 6(a-e): User beam Receive Antenna Gain Contour at scan for (a) Phase 1 and 2: 700 km, (b) Phase 2: 690 km, (c) Phase 3: 400 km, (d) Phase 3: 390 km, and (e) Phase 3: 380 km

III. Astra's Interference Mitigation: Coordination and PFD Compliance (25.261, 25.271(a)(2))

Astra remains committed to collaborative operation of its Constellation, both for radio frequency operations and physical space operations, and will seek to coordinate and collaborate to the greatest degree possible. In accordance with Section 25.273(c), Astra will maintain a complete and accurate set of technical details of current and planned radiofrequency transmissions for their satellites and will provide any necessary technical information to other space station licensees to identify and promptly resolve any potential causes of radiofrequency interference between systems.

From a spectrum perspective, the Astra Constellation has been designed to optimize for the efficient use of assigned radio frequencies in its services delivery, while retaining sufficient flexibility to ensure coordination of spectrum with other authorized users. While Astra recognizes that the ITU has not yet adopted complete international technical standards governing NGSO use of the V-band frequencies, and that there are few existing spacecraft in any orbit that are utilizing the bands, Astra views it as essential to the orderly development of these frequencies that even early space systems plan for the technological capability to co-exist with other space-based and terrestrial users without creating harmful interference (25.203(h), 25.278, 25.289).

Astra will participate in the development of sensible rules for use of V-band, particularly those governing EPFD and protection of GSO networks by NGSO systems -- which Astra notes are ongoing at the ITU in Working Party 4A (WP-4A) -- and will design and operate its Constellation to fully comply with U.S. and international requirements as they emerge. Also in keeping with the Commissions' rules, Astra will undertake good-faith coordination with other NGSO users of the frequency bands and will exchange necessary technical parameters to avoid harmful interference and maximize spectral efficiencies across operators (25.261). Astra views operator-to-operator coordination as a superior means to utilize spectrum to the regulatory approach of band segmentation.

A. Compliance with PFD Limits (25.114(c)(8), 25.208(r), 25.208(s), and 25.208(t))

Part 25.208(r), 25.208(s), and 25.208(t) define V-band power flux density (PFD) limits, which are summarized in Table 5.

Table 5. FCC PFD Limits in the 37.5 - 42.5 GHz Band

FCC Part 25 Rule	**Frequency Range (GHz)**	**PFD Limit in dB(W/m^2) for angles of arrival above the horizontal plane**			**Reference Bandwidth (MHz)**
		0 - 5 deg.	**5 - 25 deg.**	**25 - 90 deg.**	
25.208(r)(1)	37.5 - 40.0	-132	-132 + 0.75(delta-5)	-117	1 MHz
25.208(r)(2)		-120	-120 + 0.75(delta-5)	-105	
25.208(s)	40.0 - 40.5	-115	-115 + 0.5(delta-5)	-105	
25.208(t)	40.5 - 42.0				

The FCC PFD Limits are plotted for reference in Figure 7.

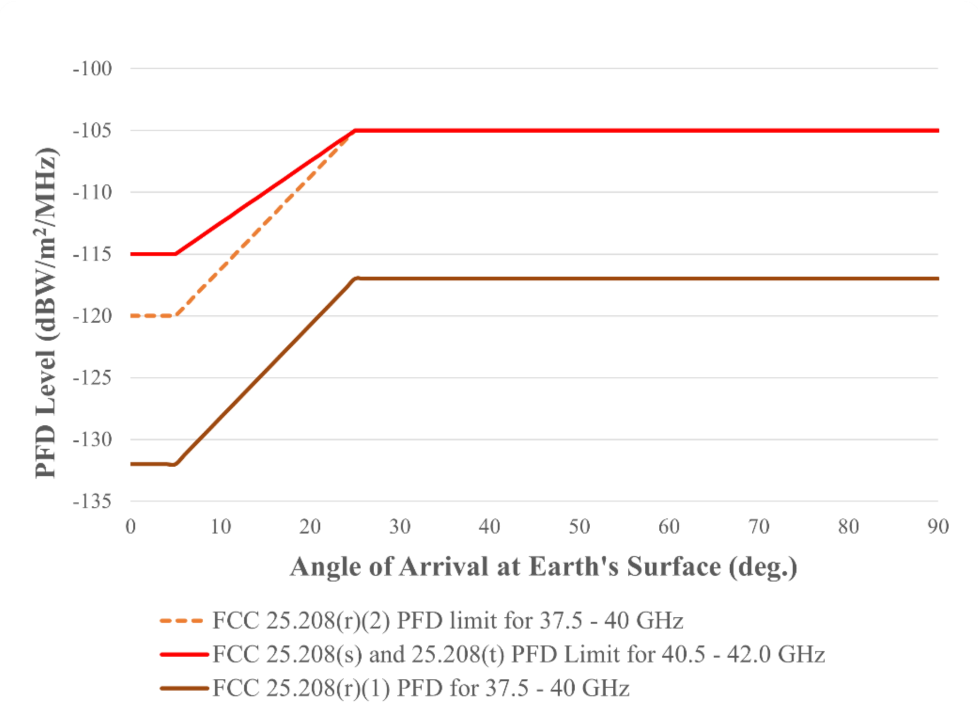


Figure 7: FCC 25.208 PFD Limits

As previously mentioned, Astra's user terminals will operate down to a minimum elevation of 20 degrees, and the orbital planes of the Constellation range in altitude from 380 km to 700 km. Given that phased arrays suffer tremendously from scan loss below 45 degrees, operations will aim to nominally maintain beams above 45 degrees and will reduce power at lower elevation angles to maintain the same PFD. A minimum elevation of 20 degrees, as well as loss due to pointing and scan are incorporated in Astra's PFD showing to ensure the highest potential interference environment. Figures are not provided for the other orbital shells, but Astra ensures that it will utilize power control, backing off power, to maintain PFD compliance.

Additionally, Astra notes that the transmissions at lower altitudes will experience steeper roll-off for low elevation angles. PFD compliance is shown assuming that beam peak arrives at the Earth surface down to the minimum elevation at which point the gain rolls off. Figure 8 shows compliance of Astra's 100 MHz user beams along with the limits codified in 25.208(r)(1) for a 700 km orbit in 37.5 – 40 GHz.

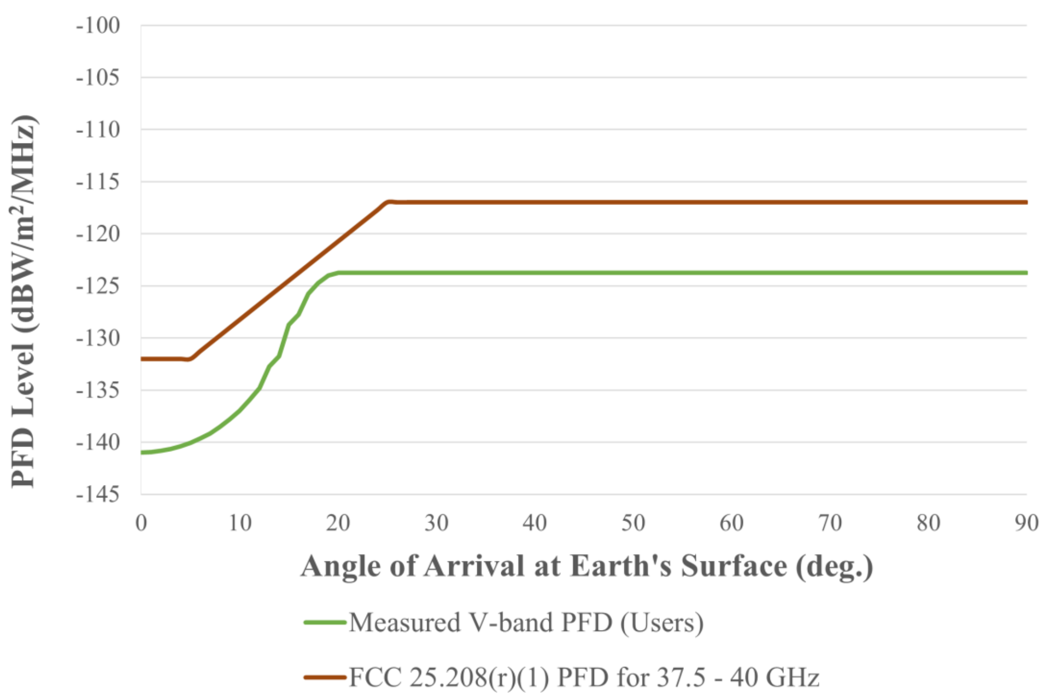


Figure 8. PFD Compliance of Astra's User Beams against 25.208(r)(1) in 37.5 – 40 GHz for a 700 km orbit

Figure 9 shows Compliance of Astra's User Beam with 25.208(r)(2) for a 700 km orbit.

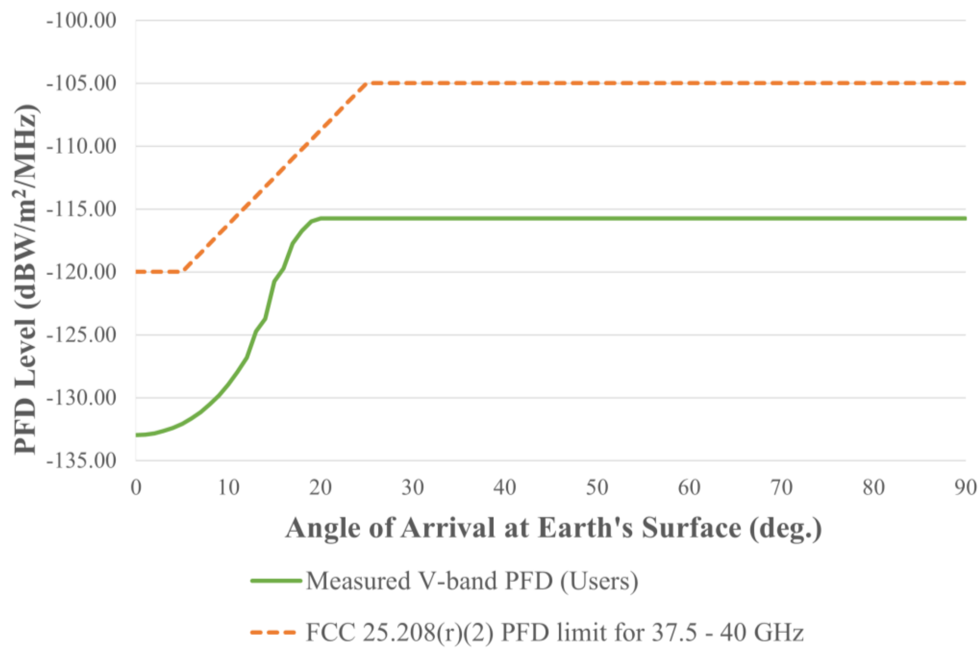


Figure 9: PFD Compliance of Astra's User Beams against 25.208(r)(2) for a 700 km orbit

Regulation 25.208(r)(2), of the Commission's rules accounts for 12 dB of rain fade during which uplink power control will be utilized. Astra baselines an 8 dB fade in its system design, thus a 4 dB additional buffer is produced.

Astra's gateways will operate down to a minimum elevation of 15 degrees. Similar to the approach provided for the 100 MHz user beams in Figure 8, Figure 10 shows compliance of Astra's 250 MHz gateway beams with 25.208(r)(1).

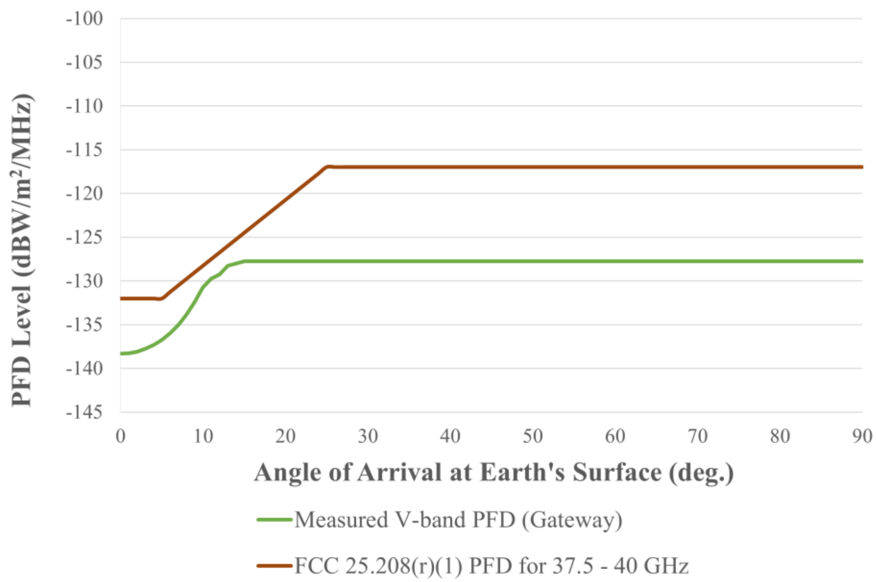


Figure 10. PFD Compliance of Astra’s Gateway Beam for a 700 km orbit

Similar to Figure 9 for User Beams, Figure 11 shows Compliance of Astra’s Gateway Beam with 25.208(r)(2) for a 700 km orbit.

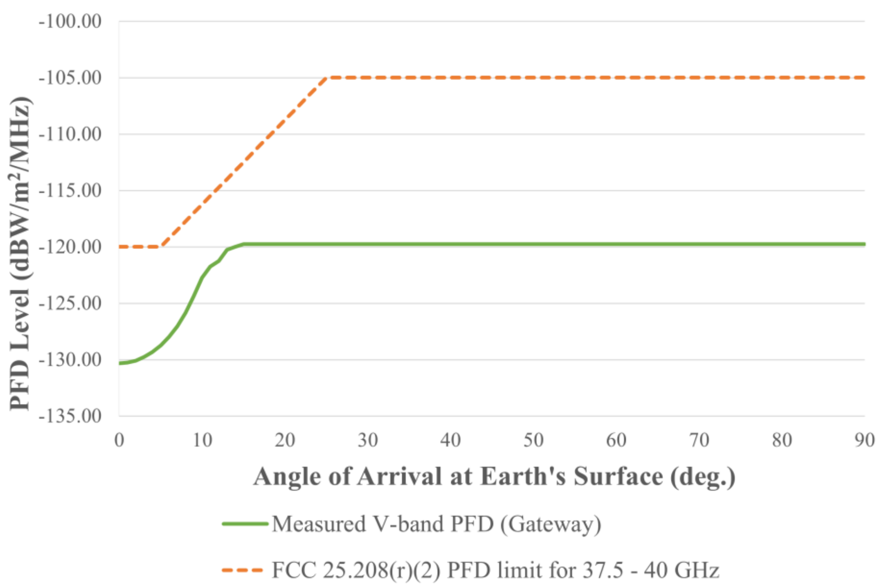


Figure 11: PFD Compliance of Astra’s Gateway Beam in 37.5 – 40 GHz against 25.208(r)(2) for a 700 km orbit

The Commission defines the PFD equally in 25.208(s) for the 40.0 – 40.5 GHz band and 25.208(t) for the 40.5 – 42.0 GHz band. Astra reiterates that it asserts it will comply with all appropriate PFD limits including 25.208(s) and 25.208(t). Compliance for Astra's User Beams, which are 100 MHz in bandwidth is shown with the limit in Figure 12.

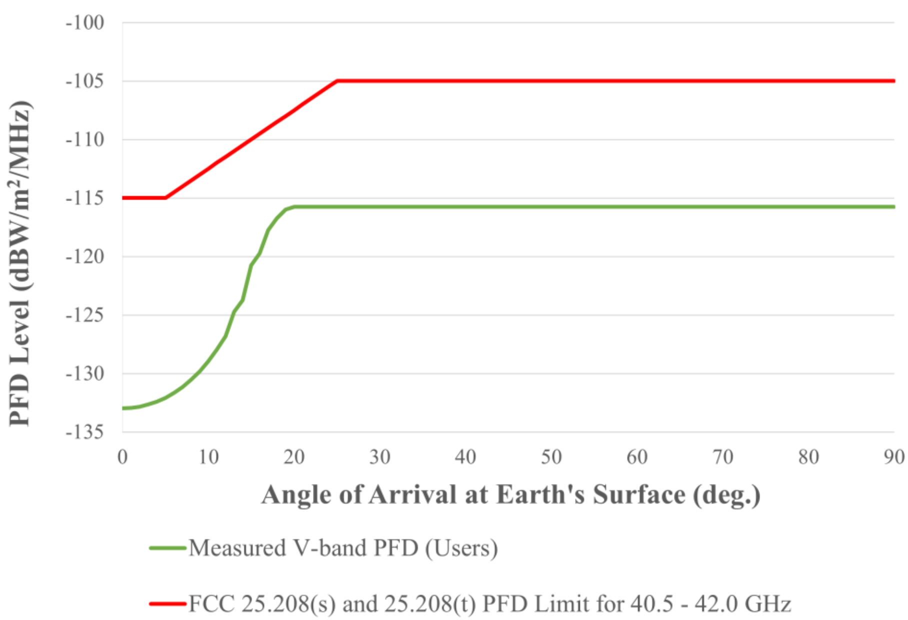


Figure 12: PFD Compliance of Astra's User Beams in 40.0 – 42.0 GHz against 25.208(s) and 25.208(t) for a 700 km orbit

Compliance of Astra's Gateway Beams, which are 250 MHz in bandwidth, is provided in Figure 13.

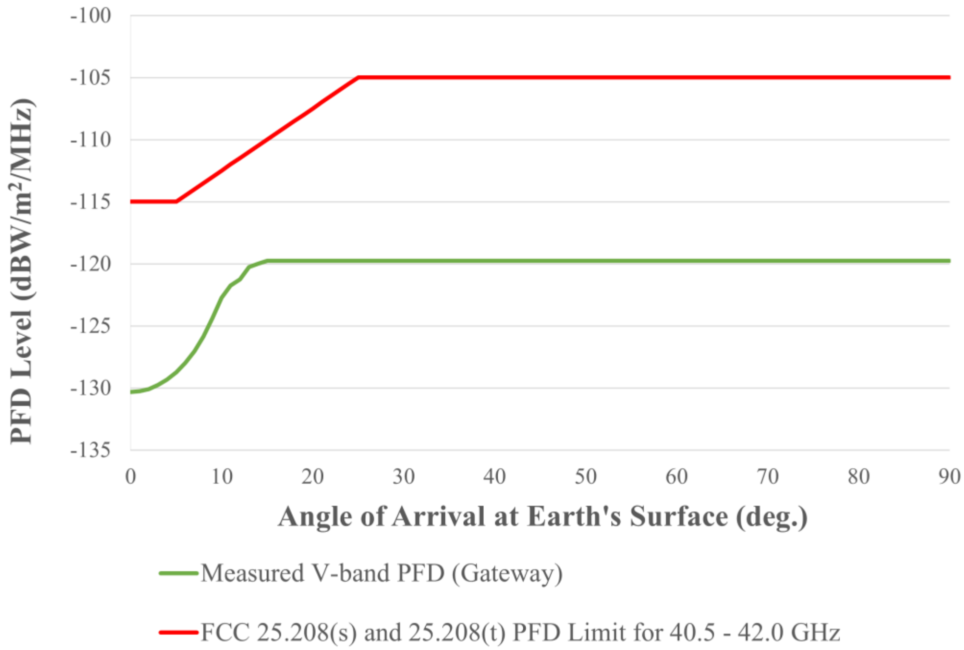


Figure 13: PFD Compliance of Astra's Gateway Beams in 40.0 – 42.0 GHz against 25.208(s) and 25.208(t) for a 700 km orbit

Lastly, Figure 14 shows compliance of Astra's 2 MHz telemetry beam with 25.208(r) of the Commission's rules, as the telemetry channels will be contained entirely in the 37.5 - 40.0 GHz band.

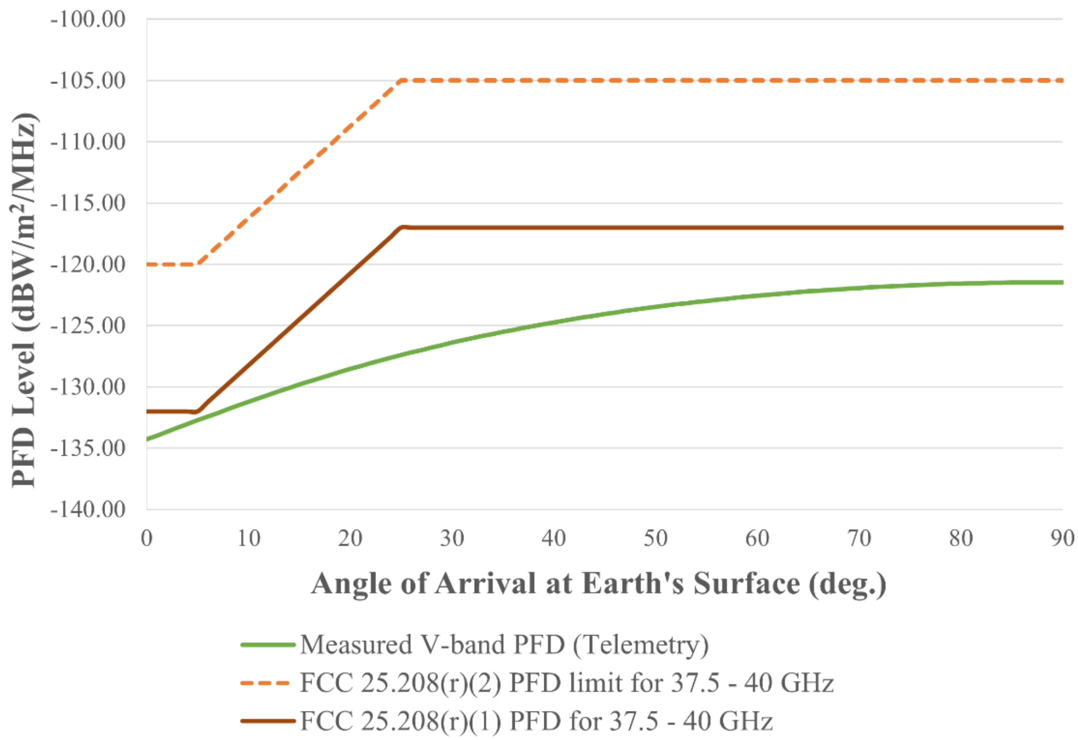


Figure 14. PFD Compliance with Astra's Telemetry Beams for a 700 km orbit

Lastly, Astra acknowledges Article 21 of the ITU's Radio Regulations, which govern PFD, are consist with the Commission's rules in the 40.5 - 42.0 GHz band but contain conditions in the two other portions of V-band FSS downlink spectrum, 37.5 - 40.0 GHz and 40.5 - 42.0 GHz, that state the limits apply for systems operating with 99 or fewer satellites. The footnote states that further studies concerning the applicability of these values are necessary to apply them to systems of 100 or more satellites. Astra has concerns that the FCC's rules should also be studied for systems, like Astra's with more than 100 satellites.

IV. Astra's Orbital Debris Mitigation Plan (25.114(d)(14))

Astra is building its Constellation with the ability to meet or exceed all U.S. and international requirements for space safety and employing industry best practices for safe space operations. In accordance with 25.114(d)(14), this section contains a description of the design and operational strategies that Astra will use to safely operate its Constellation and ensure the mitigation of orbital debris. Given that Astra has not yet completed Critical Design Review (CDR) for its spacecraft, Astra has deemed it inappropriate to prematurely submit results from NASA's Debris Assessment Software (DAS), but asserts that it will comply with all of the Commission's orbital debris related requirements. Furthermore, Astra will promptly furnish compliance with NASA's NS 8719.14B, or an updated version, based on simulations using NASA's DAS once its mass and volume budgets have been appropriately developed.

Astra will design its spacecraft and space operations approach to comply with Section 25.114(d)(14)(i) of the Commission's rules, and will carefully evaluate the amount of debris expected to be released in a planned manner during normal operations. The space vehicle deployables, which include solar arrays and gimballed gateway reflectors, will be designed and validated to eliminate any debris released. All hold-down release mechanisms will be self-contained devices, further reducing creation of debris.

Astra spacecraft will include state of the art propulsion systems, and Astra has diligently sized its propellant budget to include allotment for orbit raise, collision avoidance, and de-orbit maneuvers throughout the spacecrafts' operational lifespan. To limit the probability either of accidental explosions or of release of liquids that would persist in droplet form, Astra will utilize an inert gas system that will be maintained in a gaseous state throughout the mission, as opposed to hypergolics or catalyst combustible propellants. This will permit Astra spacecraft to safely and precisely conduct orbital maneuvers throughout the duration of the mission and at end-of-life (25.114(d)(14)(iii)). At end-of-life, each spacecraft's batteries will be depleted as part of the decommissioning process and maintained at a discharged state, and the propellant tank will be passivated and the remaining propellant will be assessed and verified to meet stored energy requirements.

Astra's choice of operational altitudes for its Constellation also supports the orbital debris mitigation plan. More than 80% of all satellites in the Constellation will orbit at 400 km or lower. At this very low altitude, atmospheric drag serves to accelerate de-orbit of any satellite that has either been commanded to de-orbit or become inactive. This helps ensure there is a low risk of creating persistent orbital debris.

V. Schedule S Description of Beam ID and Gain Contour Beam ID Mapping

Astra has uploaded "Astra_GIMS" in its Schedule S. This GIMS file contains GXT contour files for a Tx and Rx beam at each orbital shell. The beam_ids for these beams are defined as QTX380, QTX390, QTX400, QTX690 and QTX700, where Q designates "Q-band", Tx designates Transmit and the last three numbers represent altitude, and VRX380, VRX390, VRX400, VRX690, VRX700, where V designates "V-band" and Rx designates Receive.

In Schedule S, Astra has defined its satellite beams such that there are eight receive beams (four beams at both RHCP and LHCP) and ten transmit beams (five beams at both RHCP and LHCP). For the receive beams, the naming convention is: Gateway Uplink RHCP Lower V-band (GURL), Gateway Uplink LHCP Lower V-band (GULL), Gateway Uplink RHCP Upper V-band (GURU) and Gateway Uplink LHCP Upper V-band (GULU), with the G replaced by a U for the User link. On the Transmit side, the twelve beams account for six beams at both RHCP and LHCP, three of which are gateway and three of which are users. The naming convention for the gateway beams is Gateway Downlink RHCP (RDL1) and Gateway Downlink LHCP (GDL1) for the FSS bands 37.5 – 42.0 GHz, Gateway Downlink RHCP (GRD2) and Gateway Downlink LHCP (GDL2) for the MSS bands 39.5 – 40.0 GHz, and lastly Gateway Downlink RHCP (GDR3) and Gateway Downlink LHCP (GDL3) for the MSS 40. – 42.0 GHz bands. For user beams, the G is replaced with a U, but all else holds true.

Each of the five GXT files, which represent contours at different altitudes are mapped to each Schedule S Beam, eight of which are on the receive side (four beams at both RHCP and LHCP), and ten of which are on the transmit side (five beams at both RHCP and LHCP).

ENGINEERING CERTIFICATION

I hereby certify that I am the technically qualified person responsible for the preparation of the engineering information contained in this Application of Astra Space Platform Services, LLC for Authority to Launch and Operate a Non-Geostationary Satellite System in V-band frequencies, that I am familiar with the Commission's Part 25 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.

/s/ Chris Kemp
Chris Kemp
CEO
Astra Space Platform Services LLC

Date: November 4, 2021