Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, DC 20554

In the Matter of	)	
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Karousel LLC	)	
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Application for Authority	)	
to Launch and Operate a	)	File No.
Non-Geostationary	)	
Earth Orbit Satellite System	)	
in the Fixed Satellite Service	)	

APPLICATION

Karousel LLC
Monish Kundra
Sharon Lam
Ron Olexa
Columbia Capital
204 South Union Street
Alexandria, VA 22314
703-519-2000

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APPLICATION

Karousel LLC ("Karousel"), pursuant to sections 308 and 309 of the Communications Act of 1934, as amended, 47 U.S.C. sections 308 and 309, requests authority from the Federal Communications Commission ("Commission") to launch and operate a non-geostationary satellite orbit ("NGSO") fixed satellite service ("FSS") system operating in an elliptical, geosynchronous orbit with a high degree of inclination to the Earth and operations in the 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-19.3 GHz, 19.7-20.2 GHz, and 27.5-30.0 GHz bands.[1]

I. INTRODUCTION

Karousel is a new, first-of-its-kind satellite-based video and data distribution platform. Karousel will rely on up to four operational satellites operating in each of the three global regions in highly inclined, elliptical, non-geostationary orbits to offer consumers and programmers a new avenue to consume and share video and data on demand. If granted, this

[1] Public Notice, OneWeb Petition Accepted for Filing, IBFS File No. SAT-LOI-20160428-00041 (SPB July 15, 2016) (inviting applications for NGSO-like satellite operation in the 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 27.5-28.35 GHz, 28.35-29.1 GHz, and 29.5-30.0 GHz frequency bands).

Application will permit Karousel to combine proven satellite technology with state-of-the art user equipment ("UE") to help bridge the urban-rural divide for access to video content while increasing avenues to diverse video and data content in the United States.

Based upon an algorithm that predicts top content likely to be requested by consumers, along with known customer preferences, Karousel's constellation will regularly deliver fresh content to Karousel UE on the ground as the satellites pass over user locations during orbit. The Karousel UE locally caches the content delivered from Karousel's various satellites so that it may be consumed at the convenience of the user. Because the content is stored locally, rather than in the cloud or at a content distribution network ("CDN") reliant on a broadband connection for delivery, the user never faces latency, buffering, or network outages; the user can access video free from the pay-TV and broadband bottleneck.

A typical user installation will include an inexpensive broad-beam or beam-forming planar or dish antenna, short-term memory receiver/storage drive with tuners and processors, and a hard disk drive and solid state drive to store video content. Karousel expects to offer a variety of equipment options at a range of price points, reflecting different storage and processing options.

Karousel will distribute a range of video programming including movies, television shows, documentaries, and news depending on user preferences. The company intends to cultivate partnerships with independent programmers interested in distributing on-demand content to end users without a cable service provider serving as an intermediary. Users will access the video through an app running on the Karousel UE or on third-party devices such as streaming media players, smartphones, and tablets. Users will be able to tailor their subscription

to their needs by choosing from different packages of video programming and on-demand selections for a-la-carte content.

Karousel's unique model of delivering and caching over-the-top ("OTT") content will offer new video options for rural consumers who may otherwise lack sufficient broadband connectivity for OTT video services. Karousel will also complement mobile broadband service to provide a true "cord cutter" alternative to cable and fiber broadband service for video-consuming households. The very existence of the Karousel platform will apply competitive pressure to cable and fiber broadband services. Finally, Karousel will offer enterprise data distribution services to government and commercial users. Generally, Karousel will improve competition in the video and broadband marketplaces, augment the nation's broadband infrastructure, and provide more options for accessing mission-critical data in remote places or wherever consumers require access to a physically redundant network.

A detailed description of Karousel's service and a statement discussing the many public interest benefits offered by Karousel's service are provided in Part II of this Application. Part III of this Application contains a detailed description of the NGSO System as well as the narrative information required by Part 25 of the Commission's rules. Part IV contains the waiver requests required by this Application and the justifications for their grant. Part V discusses how the Karousel system will share spectrum with other authorized users. The significant public interest benefits of increasing access to and the affordability of on-demand content for consumers and content creators should permit the Commission to grant this Application promptly.

II. PUBLIC INTEREST BENEFITS

A. Introduction

Karousel plans to offer a "celestial video jukebox" service that focuses principally on providing high-quality, on-demand content—particularly video content—to consumers for whom video over broadband is either inaccessible or unaffordable. Karousel will offer new video options for rural consumers who may otherwise lack sufficient broadband connectivity for OTT video services through a constellation of twelve non-geostationary orbit ("NGSO") satellites in inclined, elliptical orbits over the United States and other areas throughout the world. Karousel will also complement mobile broadband connectivity with high-quality, in-home video content, providing cord cutters with a new competitive alternative to fixed broadband connections. Finally, Karousel will offer enterprise data-distribution services to government and commercial users. Karousel's advanced satellite system will improve competition for the delivery of stand-alone and bundled video services, augment the nation's broadband connectivity, and provide more options for accessing mission-critical data in remote places or wherever consumers require redundant network systems.

B. Market Opportunity

Consumers in the video marketplace want choices for video services with options that are better suited for their unique video consumption patterns and preferences. The U.S. market for OTT video services is booming because OTT services provide attractive alternatives to the traditional expensive cable bundle. But many consumers' needs are still not being met. Many rural consumers simply do not have broadband connectivity capable of supporting OTT video. And non-rural consumers who have such connectivity often find it expensive. Moreover, bottlenecks in the video-distribution market also prevent online video distributors ("OVDs") and other alternate video providers, as well as small and independent programmers, from offering

competitive alternatives to consumers because these services all rely on incumbent broadband Internet access service ("BIAS") or pay-TV providers to reach their end users.

These challenges also present opportunities, which Karousel intends to pursue. Karousel will augment existing infrastructure to provide a viable, cost-effective video solution for rural consumers and a competitive option to non-rural cord cutters seeking an alternative to cable or fiber broadband for access to video content.

1. Streaming video is driving sharp increases in demand for broadband connectivity.

Consumer Internet traffic is growing rapidly in the United States, driven in large part by video consumption. According to Cisco, U.S. Internet video traffic was 10.5 exabytes per month in 2015.[2] To provide some sense of scale, just ten exabytes could hold all of the content of the Library of Congress 5,000 to 30,000 times over. And Cisco projects that this figure will more than triple to 34.4 exabytes per month in 2020.[3] According to Cisco, Americans consumed nearly 600,000 years of Internet video content in 2015, accounting for 76% of consumer Internet traffic in 2015 (up 37% from the previous year).[4] Cisco expects video will represent an even larger share—85%—of U.S. consumer Internet traffic by 2020.[5]

The large number of people dropping traditional cable television service in favor of OTT video services contributes significantly to the volume of data used to watch video. Each year since 2013, the number of customers dropping cable television service outnumbers those

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[2] *VNI Complete Forecast Highlights Tool, United States*, CISCO, http://bit.ly/1U45JDS (last visited Nov. 8, 2016) ("*Cisco*").

[3] *Id.*

[4] *Id.* ("In the United States 306 billion minutes (581,962 years) of video content crossed the Internet each month in 2015. That's 116,392 minutes of video streamed or downloaded every second.").

[5] *Id.*

subscribing to a new account.[6] And roughly half of the approximately 125 million households in the United States now subscribe to at least one video streaming service.[7] Netflix alone has 46 million paid U.S. subscribers as of the third quarter of 2016; Amazon Prime has more than 55 million video service subscribers; Hulu has another 12 million;[8] HBO Go reported 800,000 subscribers as of early 2016;[9] and Sling TV reported more than 600,000 subscribers as of February 2016.[10]

Americans' appetite for online video burdens the nation's broadband infrastructure and raises the stakes for broadband competition. The network equipment company Sandvine estimates that Netflix, Amazon Prime Video, and iTunes together account for more than 40% of all peak Internet traffic in the U.S., and YouTube accounts for another 18% of peak traffic.[11] The

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[6] *Cutting the cord*, THE ECONOMIST (Jul. 16, 2016), http://econ.st/2a5ejAV ("*Cutting the Cord*"); Brad Tuttle, *A Record Number of People Just Cancelled Their Pay TV Subscriptions*, TIME.COM (Aug. 31, 2016), http://ti.me/2eMEKdc (explaining that 812,000 U.S. customers canceled pay TV subscriptions in the second quarter of 2016 alone).

[7] *See Cutting the Cord*; *see also Number of Households in the U.S. from 1960 to 2015 (in millions)*, Statista, https://www.statista.com/statistics/183635/number-of-households-in-the-us/ (last visited Nov. 6, 2016).

[8] *Netflix Q3 Letter to Shareholders*, NETFLIX.COM (Oct. 17, 2016), http://bit.ly/2eRuZL4; *Number of Hulu's paying customers from 4th quarter 2010 to 2nd quarter 2016*, http://bit.ly/2fPdm3a (last visited Nov. 8, 2016).

[9] Shelby Carpenter, *With Only 800,000 Subscribers, HBO Now Can't Keep Up With Netflix*, FORBES.COM (Feb. 10, 2016), http://bit.ly/2eDcb4B.

[10] Shalini Ramachandran, *Dish Network's Sling TV Has More Than 600,000 Subscribers*, THE WALL STREET JOURNAL (Feb. 18, 2016), http://on.wsj.com/1RaPXSN.

[11] Sandvine 2016 Global Internet Phenomena: Latin America & North America (Oct. 2016), https://www.sandvine.com/trends/global-internet-phenomena/.

migration to high definition ("HD") and, soon, ultra-high definition ("UHD") content, strains the capacity of existing broadband networks.[12]

The demands will continue to increase. Netflix, for example, recommends a 5 Mbps connection for HD content and 25 Mbps for UHD content.[13] An HD video stream can consume up to 3 GB per hour and a UHD stream consumes 7 GB per hour.[14] Of course, any given household may demand more than one stream at any given time and these streams compete for bandwidth with other Internet uses.[15] This year, Sandvine reported that the average North American household has seven Internet-connected devices.[16] The increasing adoption of video streaming and corresponding multi-user trend drove the Commission to redefine high-speed broadband in 2015 as a 25 Mbps connection, up from 4 Mbps.[17] These demands also require

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[12] *See* EchoStar Corporation, Quarterly Report (Form 10-Q) (Nov. 7, 2016) (reporting EchoStar's Hughes division is adding fewer broadband subscribers in part due the lack of capacity in certain areas).

[13] *Internet Connection Speed Recommendations*, Netflix.com, https://help.netflix.com/en/node/306 (last visited Nov. 7, 2016).

[14] *How Can I Control How Much Data Netflix Uses?*, Netflix.com, https://help.netflix.com/en/node/87 (last visited Nov. 7, 2016).

[15] *See, e.g.*, Prepared Remarks of FCC Chairman Tom Wheeler, The Facts and Future of Broadband Competition, 1776 Headquarters, Washington, DC (Sept. 4, 2014), http://bit.ly/1o1tQ0F ("It's not uncommon for a U.S. Internet-connected household to have six or more connected devices. . . . When these devices are used at the same time, as they often are in the evenings, it's not hard to overwhelm 10 Mbps of bandwidth."). Time Warner Cable says the company's average household usage in December was 141 gigabytes a month, and has grown 40% a year. More than two million Comcast customers use more than 300 gigabytes a month. *See* Thomas Gryta and Shalini Ramachandran, *Broadband Data Caps Pressure 'Cord Cutters,'* THE WALL STREET JOURNAL (Apr. 21, 2016), http://on.wsj.com/1T1GeMP ("*Broadband Data Caps Pressure 'Cord Cutters*'").

[16] Press Release, Sandvine, Sandvine Report: North American Homes Average Seven Active Connected Devices (Aug. 24, 2016), http://bit.ly/2efEfMG.

[17] *See Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the*

BIAS providers to make extensive ongoing investments in their networks, which can put upward pressure on broadband prices for consumers.

2. Many Americans face obstacles accessing diverse and affordable video content online.

Many consumers face real challenges in accessing video content online, whether due to availability, affordability, or slow connection speeds. Americans face three different types of problems in accessing on-demand or Internet video services. First, those in rural areas have limited ability to access any on-demand video content because the available infrastructure does not support it. Second, mobile subscribers in all regions of the country find their service cannot affordably support video streaming to their TV. Third, even Americans who rely on OTT today by using expensive fixed broadband services confront overage charges due to huge volumes of data consumed by OTT video.

a) Rural consumers have few options for watching OTT video content.

Nowhere is the burden of Americans' appetite for on-demand video felt more acutely than in rural areas. Much of rural America relies on low-capacity, slower-speed Internet connections. According to the Commission, 34 million Americans lack access to 25 Mbps/3 Mbps service, two thirds of whom live in rural areas.[18] And some 20 million Americans lack

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Broadband Data Improvement Act, 2015 Broadband Progress Report and Notice of Inquiry on Immediate Action to Accelerate Deployment, GN Docket No. 14-126, ¶ 3 (Feb. 4, 2015) ("*2015 Broadband Progress Report*").

[18] *See Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act*, 2016 Broadband Progress Report, 31 FCC Rcd. 699 ¶ 79 (2016) ("*2016 Broadband Progress Report*").

access even at 10 Mbps/1 Mbps.[19] Many of these citizens can access the Internet only over satellite broadband or long-loop DSL connections, but both services are unsuited to support delivery of large amounts of individualized video content.

From a public policy perspective, the growth of OTT video puts the broadband availability gap into ever-starker relief. The availability of an OTT viewing experience today depends on the availability of a broadband Internet connection. Consumers without Internet access capable of reliably supporting streaming media cannot enjoy OTT video and its unique benefits, such as original content, "binge watching" of multiple episodes and seasons of programming, and a greater variety of children's, major regional, and special interest content and minority focused programming, than is available over traditional over-the-air or cable platforms. The cost to fill this gap by deploying faster, higher capacity systems in these areas may be exorbitant even with subsidies from the Connect America Fund and other sources.

b) Demands of OTT video prevents many mobile-only households from truly cutting the cord.

Even in areas where cable and fiber are available, many consumers choose to "cut the cord" by relying on cellular service as the primary means of Internet access. This phenomenon is particularly apparent among low-income households who cannot afford both cellular and fixed-line service or who move frequently. Last year 13% of adults used only smartphones to connect to the Internet, up from 8% in 2013, according to a Pew Research Center study.[20] Yet consumers report that they prefer to watch video content on a television or computer screen, as opposed to their mobile device. As the Pew Research Center explained in a 2015 study, "when given a choice, people prefer to use their smartphone for getting in touch with family or friends,

[19] *See id.*

[20] *Home Broadband 2015*, PEW RESEARCH CENTER (Dec. 21, 2015), http://pewrsr.ch/1mf2ZDX.

but for watching video, they prefer a device with a larger screen."[21] Unfortunately, big-screen video consumes a lot of bandwidth and practical limitations on cellular connectivity mean that many "cord cutters" cannot fully substitute mobile for fixed broadband service.

While cellular LTE now can provide high-speed broadband service, inherent limitations on system capacity limit the ability for true cord cutters (*i.e.*, those without fixed broadband at home) to consume substantial quantities of long-form video content, such as full-length television programs and feature-length movies. Watching just a few HD movies, for example, can easily cause a family to exceed its mobile broadband data cap, which, depending on the provider, can trigger expensive overage fees or reductions in data rate that make further OTT viewing impossible. In other words, most so-called "cord cutters" cannot actually cut the cord because they consume too much video to make this step cost effective in the long run.

c) All OTT video users could use a competitive alternative to data-capped fixed broadband connections.

Even households that do not subscribe to pay TV, but have fixed broadband subscriptions, face data caps that limit their ability to consume OTT video content. Most Americans continue to have one only one choice for high-speed broadband—their cable operator—and thus depend on the service provider from which they are seeking alternatives.[22] Some consumers who were once "cord-cutters" are canceling streaming services and returning to cable service to avoid the high costs of streaming high volumes of video content over their fixed

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[21] *Id*.

[22] *See* Brad Tuttle, *A Record Number of People Just Cancelled Their Pay TV Subscriptions*, TIME.COM (Aug. 31, 2016), http://ti.me/2eMEKdc; *see also Next 10 Years Look Upbeat for the U.S. Cable Industry*, S&P Market Intelligence (Aug. 11, 2016), http://marketintelligence.spglobal.com/our-thinking/newsroom/next-10-years-look-upbeat-for-the-u-s-cable-industry (predicting that while TV subscriptions will decline 1.5% per year over the next ten years, broadband subscriptions will increase by 8 million over the same period).

and wireless broadband connections.[23] As the Wall Street Journal put it, some Americans "are facing [data limits] in their living rooms as their home Internet providers require them to ration Web usage or pay surcharges."[24] These problems are symptomatic of a market structure in which all roads lead back to the cable company and its fixed broadband infrastructure. Consumers lack competitive options that combine fast broadband access with affordable OTT video content.

3. Bottlenecks in the broadband and cable market present obstacles for video distributors and independent programmers.

Consumers are not the only group adversely affected by the bottlenecks in the video distribution marketplace. Upstream programmers, OTT platforms, and stand-alone video providers are also beholden to large pay-TV and BIAS providers to deliver their content to consumers.

Despite the proliferation of platforms enabling consumer access to video content, a handful of large companies still maintain control of video distribution. A majority of households still subscribe to cable,[25] and most customers who shaved or cut the cable cord still rely on their local broadband provider for connection to OTT services. AT&T/DIRECTV, Charter/Time Warner Cable, and Comcast control access to a majority of consumers seeking video content.[26]

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[23] *See* Brad Tuttle, *A Record Number of People Just Cancelled Their Pay TV Subscriptions*, TIME.COM (Aug. 31, 2016), http://ti.me/2eMEKdc (reporting former Sling TV customers are dropping the service because they were charged so much in extra broadband fees they are finding it cheaper to go back to cable).

[24] *See Broadband Data Caps Pressure 'Cord Cutters.'*

[25] Kate Cox, *Survey Says: Your Bills Are Going Up, But 82% of Households Still Pay for Cable*, CONSUMERIST (Sept. 27, 2016), http://bit.ly/2cznnLa.

[26] Press Release, Leichtman Research, Major Pay-TV Providers Lost About 665,000 Subscribers in 2Q 2016 (Aug. 15, 2016), //bit.ly/2fM5ZcL (reporting AT&T/DIRECTV has approximately

Their market position in the pay-TV and broadband infrastructure markets enables these entities to exert power over programmers and video distributors alike.

To access a majority of the "eyeballs" in the United States, programmers must reach agreements with the largest MVPDs. MVPDs' bottleneck control over distribution can give them significant leverage over programmers, particularly smaller and independent programmers, to achieve below-market prices for content and to impose restrictive contract terms that prevent programmers from licensing content to OVDs and other alternate distribution systems.[27]

The significant leverage enjoyed by MVPDs also has negative effects on the ability of OVDs to offer a competitive option for consumers. First, restrictive contracts preventing programmers from licensing content to OVDs limit the catalogue of content that OVDs can offer consumers.[28] OVDs with enough resources are increasingly developing new original content,[29]

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26 million subscribers, Charter/TWC approximately has 24 million subscribers, and Comcast has approximately 22 million subscribers).

[27] In 2015, the Commission recognized that Charter's recent merger with Time Warner Cable would "likely increase New Charter's incentive and ability to use its leverage over programmers to extract contractual terms that will frustrate the programmers' abilities to license content for online distribution," and in doing so, "New Charter will foreclose online video distributors from content that allows them to be more vibrant competitors to cable operators." In response, the Commission imposed conditions limiting the ability of New Charter to impose restrictive contract terms. However, most programming negotiations are not subject to such limitations. *Applications of Charter Communications, Inc., Time Warner Cable Inc., & Advance/Newhouse P'ship*, Memorandum Opinion and Order, 31 FCC Rcd. 6327 ¶¶ 7, 213-23 (2016). Even mid-size providers lack negotiating leverage with programmers, compared to large distributors. For example, even with a significant 6 million subscribers before its merger with DIRECTV, the Commission recognized "AT&T's video product is hampered by higher costs of procuring programming—limiting its ability to both offer lower consumer prices and expand its high-speed broadband footprint." *Applications of AT&T Inc. & DIRECTV*, Memorandum Opinion and Order, 30 FCC Rcd. 9131 ¶ 3 (2015).

[28] Karl Bode, *Vox Joins Growing Chorus of Outlets Weirdly Crapping on Cord Cutting*, TECHDIRT (Oct. 19, 2016), http://bit.ly/2fajVvA ("[C]onsumers are growing increasingly frustrated with and confused by exclusive, temporary licensing and vanishing streaming catalogs.").

but consumers still overwhelmingly demand a handful of popular shows, and for many smaller OVDs or other distributors, creating original content is simply not an option. Second, even if OVDs can build a strong catalogue of content, they rely on large broadband providers to deliver streaming video content to consumers. Even though the Commission has adopted open Internet rules that prohibit BIAS providers from blocking or throttling OVD content or engaging in paid prioritization practices,[30] BIAS providers, particularly mobile broadband providers, still have the incentive to discriminate against OVDs. BIAS providers are, for example, increasingly adopting zero-rating practices that exempt their own or affiliated content from data caps, which drives consumers toward data-usage-exempt content and away from OVD services.[31]

In a market where even the largest programmers lack substantial bargaining leverage against MVPDs, the challenges independent programmers face obtaining carriage can be significant. For many smaller programmers, one of the only ways to obtain carriage is to accept take-it-or-leave-it agreements from MVPDs including provisions that impair or prohibit the

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[29] *See id*. ("[T]he same companies setting licensing rates for traditional cable also set the licensing rates for streaming alternatives. As such, pricing for both is probably going to higher than anybody would like, and that's why Hulu, Amazon and Netflix are feverishly developing original content.").

[30] *See Protecting and Promoting the Open Internet*, Report and Order, 30 FCC Rcd. 5601 (2015) ("*2015 Open Internet Order*"). OVDs such as Netflix have complained that broadband providers like Comcast and AT&T have degraded their own customers' access to Netflix's service to push customers toward the MVPDs' own pay-TV services. While these practices are now prohibited by the open Internet rules, broadband providers may find other ways to harm OVDs that are dependent on their broadband infrastructure. *See* Letter from Markham C. Erickson, Counsel to Netflix, Inc. to Marlene H. Dortch, FCC, MB Docket No. 14-57, at 2 (May 4, 2015), https://ecfsapi.fcc.gov/file/60001046398.pdf; *see also* Petition to Deny of Netflix, Inc., MB Docket No. 14-57, at 75-89 (Aug. 27, 2014), https://ecfsapi.fcc.gov/file/7521819696.pdf.

[31] *See 2015 Open Internet Order* ¶ 339.

distribution of content through online platforms.[32] These programmers, OVDs, and consumers lack access to content as a result. New facilities-based competition could help address all of these issues without any regulations.

C. Karousel System and Services

By partnering with leaders in the satellite industry, Karousel has developed an innovative solution to address gaps in the video distribution market. Karousel's model will offer the world's first high-capacity broadcast data delivery system that combines satellite content delivery with terrestrial caching and storage to give consumers access to OTT content even when they lack broadband connectivity.

Karousel's satellite constellation, which will eventually consist of up to twelve non-geostationary satellites (up to four in the first phase), will regularly deliver fresh content to Karousel UE on the ground as its satellites pass over user locations during orbit. The satellites will feed new content to the UE based on an algorithm that predicts the top-content likely to be requested by consumers. Karousel's satellites do not deliver a constant live stream of data to a given user location but instead regularly deliver OTT programming to the UE for local storage so that consumers can access the programming when they are ready to view it.

Soon after initiating service, a user will have a rotating collection of popular digital content pre-loaded to her UE, without having to request a single show. If a user seeks access to

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[32] *See Promoting the Availability of Diverse Sources of Video Programming*, Notice of Inquiry, MB Docket No. 16-41 (Feb. 18, 2016), http://bit.ly/2fLXj6i (finding that "incumbent operators retain a very important position in the video programming marketplace. Although competition among video distributors has grown, traditional [MVPD] carriage is still important for the growth of many emerging programmers," and "independent video programmers have expressed concern that certain carriage practices of cable operators and other MVPDs may limit their ability to reach viewers."); *see also* Reply Comments of Public Knowledge, MB Docket No. 16-41 (Apr. 19, 2016), http://bit.ly/2fM06wk.

content that has not already been cached on the UE, the system will process the user's request and will deliver the content to the UE, typically within 24 hours as various in-orbit satellites refresh the user's stored content. The locally stored material will improve over time as the system customizes the content based on the user's needs and requests. Because the content is stored locally, rather than in the cloud or at a content distribution network ("CDN"), the user never faces latency, buffering, or network outages; the user can access video without having to rely on the pay-TV and broadband bottleneck. This system can provide users with a comparable experience to live streaming OTT content, without a broadband connection. Karousel service can augment slower/lower capacity broadband connections such as LTE or DSL with a robust OTT video experience, though it can also function on a stand-alone basis.

A typical Karousel user installation will include an inexpensive planar or dish antenna, short-term memory receiver/storage drive with tuners and processors, a hard drive to store video content, and an app running on the UE itself or another device (streaming media player, tablet, smartphone, etc.) through which to access content on a TV or other screen. The antenna and short-term memory equipment will be located outside the home. The content received by the antenna will be transferred to the user's storage inside the home via coaxial cable or Ethernet, or potentially, over a wireless connection. The receiver will also have the ability to connect to the user's local area network if one is available. Karousel expects to offer a range of equipment at various price points reflecting different hardware capabilities and storage capacities. The equipment could be installed by a trained professional for a nominal fee or could be installed by the user, similar to the installation of DBS equipment.

Karousel will distribute a range of video programming including movies, television shows, documentaries, and news depending on user preferences.[33] High-bandwidth satellite delivery, combined with high-capacity local storage will allow Karousel to offer not only highly popular content but also "long-tail" selections representing a great diversity of programming options. Karousel will seek partnerships with both independent programmers and existing OTT content distributors. Karousel will allow these content providers to deliver their content directly to end users without an intermediary controlled by a pay-TV operator and without the bandwidth constraints associated with busy hour traffic of more traditional broadband Internet access service providers.

Karousel also intends to provide data distribution services to government and commercial enterprise users. In essence, any user that needs to transmit large datasets to multiple receive locations simultaneously can benefit from distribution over the Karousel system, particularly where traditional network access systems are limited or impaired. For example, the Karousel service could be used to rebroadcast weather radar imagery, maps and other imagery data for defense or border-security purposes. Karousel similarly could serve as a redundant backup to other space-based or terrestrial delivery methods in case of a disaster or other emergency.

D. Public Interest Benefits of the Karousel System

Karousel seeks to offer facilities-based competition in the market for OTT video. In rural areas, consumers without access to broadband can use the Karousel platform to access OTT video content for the first time and rural users with only limited broadband connectivity can use

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[33] *Turner Broadcasting System, Inc. v. FCC*, 512 U.S. 622, 663 (1994) (quoting *Associated Press v. United States*, 326 U.S. 1, 20 (1945)) (the Commission has a duty to promote diversity and competition among media voices through "the widest possible dissemination of information from diverse and antagonistic sources," a duty seen as "essential to the welfare of the public.").

Karousel for video consumption to save the limited broadband capacity available under data-capped plans for non-video uses. From a public policy standpoint, this offloading of OTT video consumption will free up capacity on rural broadband networks, providing additional flexibility to reach under-served areas with broadband that meets the Commission's 25/3 Mbps service benchmark for Internet service sufficient to enable "users to originate and receive high-quality voice, data, graphics, and video telecommunications using any technology."[34]

For non-rural or other consumers with easy access to high-speed broadband, consumers can combine Karousel with the mobile broadband service of their choice and effectively have all the benefits of broadband without the need for an additional high-speed data link for OTT video consumption. Indeed, offloading OTT video content to Karousel's system, coupled with mobile broadband, may make true cord cutting a genuine option for many households for the first time. By complementing LTE networks with a facilities-based OTT video delivery platform capable of supporting UHD content on a large screen, mobile can compete head to head with fixed broadband, leading to increased consumer choices, lower prices, and better service delivery.

The Karousel system can also alleviate congestion on other broadband networks. Video accounts for the vast majority of Internet traffic,[35] and consumers watch most video content during the same discrete busy hours.[36] This concentrated demand on broadband networks taxes

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[34] *See 2016 Broadband Progress Report.*

[35] *See Cisco* (Internet video accounted for 76% of consumer Internet traffic in 2015).

[36] *See Zettabyte Era – Trends and Analysis*, CISCO (June 2, 2016), http://bit.ly/295hnsl ("Video is the underlying reason for accelerated busy-hour traffic growth. Unlike other forms of traffic, which are spread evenly throughout the day (such as web browsing and file sharing), video tends to have a 'prime time.' Because of video consumption patterns, the Internet now has a much busier busy hour.").

the capacity of mobile and fixed broadband networks.[37] As an always-on storage platform that is continuously refreshing, Karousel will have no busy hours or network congestion and can therefore offer video offload during these periods of peak congestion. This type of video offload has two benefits. First, video offload frees the capacity of mobile and fixed broadband networks for other real-time content, such as live, two-way video communications. Second, as consumers adopt Karousel's service, the decrease in consumer use of broadband data for video watching will reduce network congestion and the attendant latency experienced by broadband customers. Reduced demand on broadband networks would reduce the costs to broadband providers to increase the capacity of their networks, which could lead to cost reductions for consumers.

Karousel's service will also offer OVD service providers and video programmers a facilities-based alternative to existing pay-TV and broadband providers, which will increase competition to the video distribution market. And, as a neutral platform without its own proprietary video service, Karousel lacks the incentive to deny OVDs and other video distributors access to Karousel's OTT video- and data-distribution service. Karousel's service will benefit smaller, independent programmers by offering a new distribution "network" for independent and niche programming that pay-TV providers will not carry, and for popular content that programmers are prohibited from licensing to OVDs or other standalone services due to restrictive contracts with pay-TV providers. Any programmer that can deliver its content to Karousel's distribution network could redistribute content nationwide over the Karousel system. Karousel will help programmers of all kinds reach new audiences.[38]

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[37] *See id*.; *see also The Total Audience Report: Q2 2015*, NIELSEN (Sept. 21, 2015), http://bit.ly/1WgcOhS (showing that consumption of video on all platforms peaks at 9 p.m.).

[38] *See, e.g., Promoting the Availability of Diverse and Independent Sources of Video Programming,* Notice of Proposed Rulemaking, FCC 16-129, MB Docket No. 16-41, ¶ 6 (Sept.

Finally, Karousel's enterprise services can help improve national security and emergency preparedness by offering government and commercial enterprise users a redundant, space-based data delivery platform for certain types of mission-critical content.

E. Experienced Investment Partners

Karousel will partner with leaders in the satellite industry to bring its innovative service to market. All of Karousel's equity holders are sophisticated or institutional investors with deep experience in the telecom sector. These leaders will be able to develop and deploy the Karousel system efficiently and effectively to bring the service to consumers in a timely fashion.

Columbia Capital and Telcom Ventures have more than $4 billion of combined capital under management and have been two of the most active investors in the satellite industry. The companies that Columbia Capital and Telcom Ventures have funded have launched eight satellites for three separate satellite systems, each the first of its kind. These investments include:

- XM Satellite Radio Holdings, Inc.: XM was one of the most innovative media distribution concepts that utilized the unique advantages of satellite. Through early funding and subsequent funding rounds, Columbia and Telcom demonstrated a commitment to the business through every stage: license acquisition, partnerships with equipment manufacturers, satellite construction/ launch, and service delivery. Prior to its merger with Sirius in 2008, XM Satellite grew to more than eight million subscribers and today the combined entities have more than 30 million subscribers.

- Mobile Satellite Ventures LP ("MSV"): Columbia and Telcom invested in MSV when the L-band in North America was controlled by two satellite companies that were both experiencing financial challenges. Simultaneous with the investment, the investors brought together American Mobile Satellite Company and TMI and put in place a space program that saw the launch of the largest and most powerful commercial MSS satellite in history.

- Terrestar Networks, Inc.: Terrestar was formed to launch a service with similar capabilities to the L-band MSV system, but on a new and then-fragmented block of 2

29, 2016) ("certain participants in the video marketplace, particularly independent content producers and OVDs, are facing significant challenges.").

GHz S-band spectrum. The investors facilitated the consolidation of the industry, which provided Terrestar sufficient spectrum and scale to launch a leading and innovative space program. Subsequently, Terrestar launched a full satellite system in the S-band and developed the world's first consumer-friendly satellite/terrestrial smartphones.

Columbia Capital also has a long history of investing in the formative stages of innovative media concepts. Some of the companies in which Columbia Capital was an early investor include:

- The Tennis Channel Holdings, Inc.: Columbia Capital was among the initial investors that launched the company, which created the world's first 24-hour cable network devoted to providing comprehensive coverage of tennis and other racquet sports.

- Fuse Media, Inc.: Columbia Capital was an early investor in SíTV Media, Inc., an English-language, cable network targeting the growing young Latino and multi-cultural TV audience. SíTV merged with the Fuse Network in 2014 and is now a leading Latino and multicultural media company, composed principally of two cable networks, Fuse and FM. Fuse reaches approximately 67 million Nielsen homes, making it the largest private independent cable network in the United States, while FM reaches more than 36 million Nielsen homes. The Company's satellite, cable and telco affiliates include AT&T, Comcast, Charter, DISH, Verizon, and Cox Communications, among others.

- Slacker, Inc.: Slacker is a comprehensive personalized music service, delivering free and subscription-based access to millions of songs and hundreds of expert-programmed stations, plus news, sports and talk. Slacker was designed from the start for mobile platforms but is also available on the web, in-car infotainment systems and most consumer electronics platforms, such as Sonos, Xbox, and PlayStation.

- Vubiquity Holdings, Inc.: Vubiquity provides fully integrated end-to-end infrastructure, services and technologies for the profitable deployment of next-generation video services. Working with nearly 650 leading film studios, television networks, independent producers and MCNs, Vubiquity brings premium content to more than 1,000 global video distributors spanning 109 million households. Through its digital distribution arm, Vubiquity is one of the world's leading providers of premium content to top OTT platforms.

- Mandalay Sports Media, LLC ("MSM"): MSM is a diversified sports content and media company that creates high-quality, sports-themed programming for all platforms and creates, acquires and invests in businesses and assets across the sports content and media landscape. Since its launch in 2012, MSM has produced content for ESPN, NFL, NBA, Netflix, HBO, Yahoo, Verizon, Hulu, ABC, Fox Sports, MLS, Sports Illustrated, A&E, Turner Sports, Legendary Entertainment, and AOL, with numerous projects in development with major television, digital, feature film, and sports entities.

The Karousel system is another example of content delivery using the latest technology and available business models. A fundamental understanding of the content industry and media delivery is critical to making such a system successful. Based on this experience, combined with a track record of backing other innovate facilities-based communications providers (including MetroPCS, Nextel, and NextNav), Columbia Capital and Telcom Ventures are uniquely experienced to launch and grow the Karousel system.

III. NARRATIVE INFORMATION REQUIRED BY PART 25

The following narrative information is required by Part 25 of the Commission's rules for NGSO FSS satellite system applications and is not addressed either by Form 312 or Schedule S to Form 312.

A. §§ 25.111(b), (d) ITUPublication Information

As required by sections 25.111(b) and (d), Karousel is preparing an ITU submission for its proposed system, including the ITU Appendix 4 notification, and will provide this information to the Commission under separate cover. Due to rule changes at the ITU, the submission will no longer be submitted as an Advance Publication, but rather a Request for Coordination.[39]

[39] The World Radiocommunication Conference, Geneva 2015 (WRC-15) adopted Resolution 31 (WRC-15), which became effective on November 28, 2015. Resolution 31 (WRC-15) deals with transitional measures for the elimination of advance publication filings by administrations for frequency assignments to satellite networks and systems subject to Section II of Article 9. Resolution 31 (WRC-15), provides that from 1 July 2016, Article 9 No. 9.1 shall cease to be applied to satellite networks or systems subject to the coordination procedures in Section II of Article 9. Accordingly and from the same date, the SpaceWISC system will cease to accept any new Advance publication information (API) filings or related amendments. Similarly, emails from administrations requesting for submission of APIs subject to coordination will no longer be accepted. *See* Final Acts WRC-15, World Radiocommunication Conference, Geneva 2015 (2015), http://www.itu.int/dms_pub/itu-s/oth/02/01/S02010000564001PDFE.PDF.

Karousel unconditionally accepts all consequent ITU cost-recovery responsibility for this filing. In relation to this submission, Karousel will execute a declaration confirming its acceptance of this responsibility and file it under separate cover.

B. § 25.113(f) Station Construction, Deployment Approval, and Operation of Spare Satellites

Section 25.113(f) provides that construction of a station for which a construction permit is not required may commence at the applicant's own risk prior to grant of a license. Karousel has attached a declaration acknowledging that, to the extent construction commences prior to grant of authorization in the proceeding, any such construction will be undertaken at Karousel's own risk.

C. § 25.114(c)(4)(i) Channel Center Frequencies, Bandwidths, and Polarization Plan for Transmitting and Receiving Beams

Section 25.114(c)(4)(i) requires applicants to provide information regarding transmit and receive channels on FCC Form 312, Main Form and Schedule S. Karousel has provided this information as required and reproduces the information here in table format for ease of reference.

RECEIVE CHANNELS					
Channel ID	T/R Mode	Channel BW, MHz	Channel CF	Polarization	F/S/T
GU1	R	250	27625	R	S
GU2	R	250	27875	R	S
GU3	R	250	28125	R	S
GU4	R	250	28375	R	S
GU5	R	250	28625	R	S
GU6	R	250	28875	R	S
GU7	R	250	29125	R	S
GU8	R	250	29375	R	S
GU9	R	250	29625	R	S
GU10	R	250	29875	R	S
GU15	R	250	14125	R	S
GU16	R	250	14375	R	S
GU17	R	250	27625	L	S

GU18	R	250	27875	L	S
GU19	R	250	28125	L	S
GU20	R	250	28375	L	S
GU21	R	250	28625	L	S
GU22	R	250	28875	L	S
GU23	R	250	29125	L	S
GU24	R	250	29375	L	S
GU25	R	250	29625	L	S
GU26	R	250	29875	L	S
GU31	R	250	14125	L	S
GU32	R	250	14375	L	S
UU1	R	250	14125	R	S
UU2	R	250	14375	R	S
UU3	R	250	14125	L	S
UU4	R	250	14375	L	S
CM1	R	5	14002.5	R	T
CM2	R	5	14497.5	R	T
CM3	R	5	14002.5	L	T
CM4	R	5	14497.5	L	T
CM5	R	5	29502.5	R	T
CM6	R	5	29997.5	R	T
CM7	R	5	29502.5	L	T
CM8	R	5	29997.5	L	T

TRANSMIT CHANNELS					
Channel ID	T/R Mode	Channel BW, MHz	Channel CF	Polarization	F/S/T
UD1	T	250	10825	R	S
UD2	T	250	11075	R	S
UD3	T	250	11325	R	S
UD4	T	250	11575	R	S
UD5	T	250	11825	R	S
UD6	T	250	12075	R	S
UD7	T	250	12325	R	S
UD8	T	250	12575	R	S
UD9	T	250	17925	R	S
UD10	T	250	18175	R	S
UD11	T	250	18425	R	S
UD12	T	250	18675	R	S

UD13	T	250	18925	R	S
UD14	T	250	19175	R	S
UD15	T	250	19825	R	S
UD16	T	250	20075	R	S
UD17	T	250	10825	L	S
UD18	T	250	11075	L	S
UD19	T	250	11325	L	S
UD20	T	250	11575	L	S
UD21	T	250	11825	L	S
UD22	T	250	12075	L	S
UD23	T	250	12325	L	S
UD24	T	250	12575	L	S
UD25	T	250	17925	L	S
UD26	T	250	18175	L	S
UD27	T	250	18425	L	S
UD28	T	250	18675	L	S
UD29	T	250	18925	L	S
UD30	T	250	19175	L	S
UD31	T	250	19825	L	S
UD32	T	250	20075	L	S
UU1	T	250	19825	R	S
UU2	T	250	20075	R	S
UU3	T	250	19825	L	S
UU4	T	250	20075	L	S
TM1	T	5	11702.5	R	T
TM2	T	5	12197.5	R	T
TM3	T	5	11702.5	L	T
TM4	T	5	12197.5	L	T
TM5	T	5	19702.5	R	T
TM6	T	5	20197.5	R	T
TM7	T	5	19702.5	L	T
TM8	T	5	20197.5	L	T

D. § 25.114(c)(4)(ii) Maximum EIRP and EIRP Density for Transmitting Beams

The maximum EIRP and EIRP density for each space station transmit beam is required by section 25.114(c)(4)(ii) and has been provided electronically for each beam on Schedule S. The values are summarized below using the same beam identifiers from Table S7 of Schedule S.

Beam ID	Maximum EIRP, dBW	Maximum EIRP density (dBW/Hz)(as shown in Form 312 Schedule S)	Max EIRP Density (expressed in units required by section 25.114(c)(4)(ii))	Units (section 25.114(c)(4)(ii))
UD1A	58.4	-24.6	11.4	dBW/4kHz
UD1B	58.4	-24.6	11.4	dBW/4kHz
UD1C	58.4	-24.6	35.4	dBW/MHz
UD1D	58.4	-24.6	35.4	dBW/MHz
UD1E	58.4	-24.6	35.4	dBW/MHz
UD1F	58.4	-24.6	35.4	dBW/MHz
UD2A	56.4	-26.6	9.4	dBW/4kHz
UD2B	56.4	-26.6	9.4	dBW/4kHz
UD2C	60.3	-22.7	37.3	dBW/MHz
UD2D	60.3	-22.7	37.3	dBW/MHz
UD2E	60.3	-22.7	37.3	dBW/MHz
UD2F	60.3	-22.7	37.3	dBW/MHz
UD3A	56.4	-26.6	9.4	dBW/4kHz
UD3B	56.4	-26.6	9.4	dBW/4kHz
UD3C	60.3	-22.7	37.3	dBW/MHz
UD3D	60.3	-22.7	37.3	dBW/MHz
UD3E	60.3	-22.7	37.3	dBW/MHz
UD3F	60.3	-22.7	37.3	dBW/MHz
UD4A	45.8	-27.2	8.8	dBW/4kHz
UD4B	45.8	-27.2	8.8	dBW/4kHz
UD4C	45.8	-27.2	32.8	dBW/MHz
UD4D	45.8	-27.2	32.8	dBW/MHz
UD4E	45.8	-27.2	32.8	dBW/MHz
UD4F	45.8	-27.2	32.8	dBW/MHz
GD5E	60.3	-22.7	37.3	dBW/MHz
GD5F	60.3	-22.7	37.3	dBW/MHz
GD6E	60.3	-22.7	37.3	dBW/MHz
GD6F	60.3	-22.7	37.3	dBW/MHz

E. § 25.114(c)(4)(v) Receive Beam Characteristics

The maximum saturation flux density ("SFD") and minimum antenna gain-to-noise-temperature ("G/T") for each space station receive beam is required by section 25.114(c)(4)(v), and has been provided electronically for each beam on Schedule S. The values are summarized below using the same beam identifiers from Table S7 of Schedule S.

Beam ID	Maximum G/T (dB/K)	Min. Saturation Flux Density (dBW/m^2)	Max. Saturation Flux Density (dBW/m^2)
UU1A	7.6	-97.6	-77.6
UU1B	7.6	-97.6	-77.6
UU2A	11.8	-101.8	-81.8
UU2B	11.8	-101.8	-81.8
UU3A	11.8	-101.8	-81.8
UU3B	11.8	-101.8	-81.8
UU4A	-5.0	-85.0	-65.0
UU4B	-5.0	-85.0	-65.0
GU5A	11.8	-95.8	-70.8
GU5B	11.8	-95.8	-70.8
GU5C	16.0	-92.0	-67.0
GU5D	16.0	-92.0	-67.0
GU6A	11.8	-95.8	-70.8
GU6B	11.8	-95.8	-70.8
GU6C	16.0	-92.0	-67.0
GU6D	16.0	-92.0	-67.0

F. § 25.114(c)(4)(vi)(B)-(D) Antenna Gain Contours

Section 25.114(c)(4)(vi) of the Commission's rules requires applicants to specify the predicted antenna gain contour(s) for each transmit and receive antenna beam for one space station for each unique orbital plane if all space stations are identical in the constellation, and this information has been provided electronically for each beam on Schedule S. All antenna beams for each unique orbit plane are presented as the same for all Karousel satellites.

The set of beams UU1A-UU1B and UD1A-UD1F have been optimized for coverage to the United States for the grouping of up to four satellites in the orbital plane that provide service in this region. Attachment 1 shows the beam contours for these satellites plotted on an area map of the surface of the earth showing the peak antenna gain. While the rule asks that applicants depict the beam pointed at nadir to a latitude and longitude within the proposed service area, the

peak gain is not depicted "at nadir" in the attachment because such a depiction would not place the beam over the United States. The contour maps are plotted at 2 dB intervals down to 10 dB below the peak gain and at 5 dB intervals between 10 dB and 20 dB below the peak gain. The contours for these beams are also shown in the attachment with examples of coverage in other regions, including South America, Europe, Africa, Asia, and Australia, although the final placement or patterns in these other regions may be different.[40] All analyses have been performed to allow full flexibility of placement of all beams across the visible Earth from the proposed orbit planes. Consistent with these limitations and as required by section 25.114(c)(4)(vi)(B)-(D) and 25.114(c)(7), Karousel has provided the predicted antenna gain contours for each beam for one space station in each orbital plane because all space stations in all orbital planes are the same.

G. § 25.114(c)(6)(i)-(ix) NGSO Orbital Parameters

Section 25.114(c)(6)(i)-(ix) requires applicants to provide the following information for non-geostationary orbits and has been provided electronically for each beam on Schedule S:

1) The number of orbital planes and the number of space stations in each plane;
2) The inclination of the orbital plane(s);
3) The orbital period;
4) The apogee;
5) The perigee;
6) The argument(s) of perigee;
7) Active service arc(s);
8) Right ascension of the ascending node(s); and
9) For each satellite in each orbital plane, the initial phase angle at the reference time.

The Karousel satellite constellation consists of up to twelve operational NGSO satellites with up to four space stations in each of three service areas. Each grouping of four satellites

[40] The global beam plot shows the overall coverage example of the six operational satellites covering the required service area at -2.5 dB; other contours are not shown because they do not fall on the Earth.

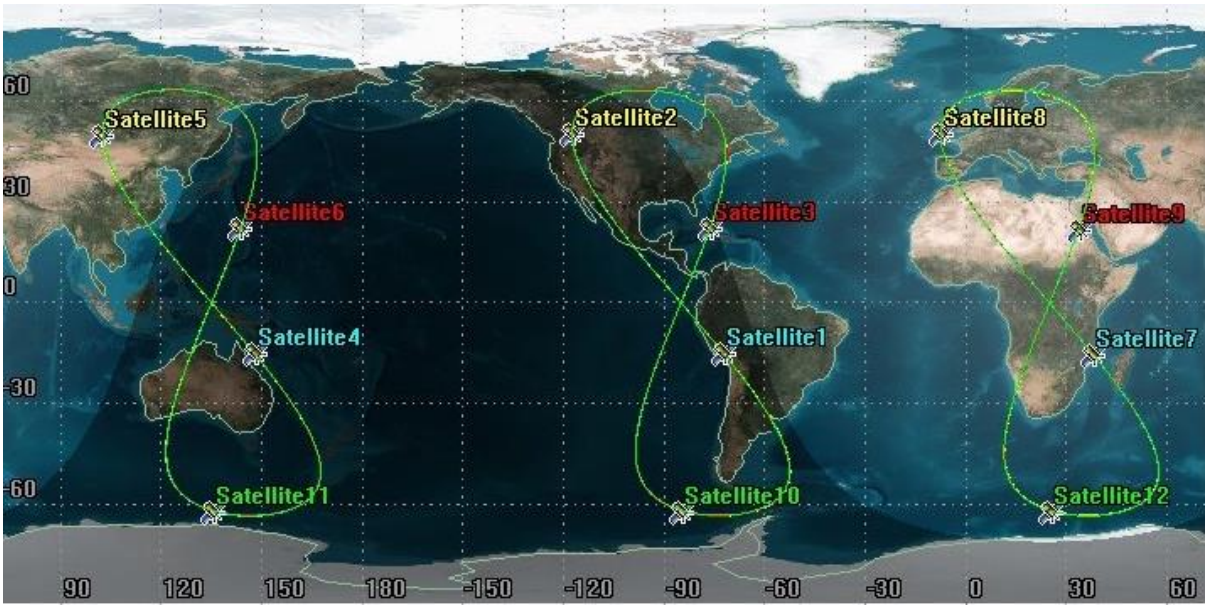
consists of one satellite in each of four inertial geosynchronous orbit planes that are oriented and phased to provide continuous coverage in both the northern and southern service areas, while providing a geostationary satellite protection zone between +35 and -35 degrees latitude.[41] The inclination and eccentricities used for the proposed system are 63.4 degrees and 0.1 respectively, with an argument of perigee of 180 degrees.[42] It is possible to modify these parameters without impacting the interference or equivalent power flux density ("EPFD") analyses in this application.

To avoid any ambiguity, the orbital parameters provided electronically on Schedule S (and in particular the right ascension of the ascending nodes) assume an epoch of 27 July 2016 at 0:00:00 UTCG. This assumed epoch is intended to result in nominal equatorial crossings of four satellites at each of 85W, 135E, and 25E longitude.

The figure below shows the ground track of the satellite constellation.

[41] The Karousel system satisfies the coverage and GSO protection requirements for antenna positions anywhere on the visible earth when using an exclusion zone of +/-35 degrees latitude and four satellites per grouping. Any future Karousel optimization of the constellation orbital parameters and specific coverage patterns will ensure all GSO protection and geographic coverage requirements are met.

[42] Schedule S does not permit the expression of negative values for the beginning angle of the active service arc in accordance with the instructions for this type of system with discontinuous service arcs. For all orbital planes the beginning of the active service arc with respect to the ascending node is -63.4 degrees and the end angle of the active service arc with respect to the ascending node is +63.4 degrees with a protection zone between -35 and +35 degrees to protect GSO space stations.



H. § 25.114(c)(7) Frequency bands, types of service, and coverage areas

Section 25.114(c)(7) requires applicants for FSS space station authorizations to provide the frequency bands it seeks authority to use, the types of service it will provide, and the areas its proposed service will cover.

Karousel seeks authority to launch an NGSO FSS system operating in an elliptical geosynchronous orbit and operations in the 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-19.3 GHz, 19.7-20.2 GHz, and 27.5-30.0 GHz bands. Karousel has provided a table of its frequencies in Part III.L.2 below. Karousel has provided a figure demonstrating its coverage with the antenna gain contours for its system in Attachment 1.

I. §§ 25.114(c)(8); 25.208 Maximum Power Flux Density Levels

Section 25.114(c)(8) of the Commission's rules requires applicants for FSS space station authorizations to provide the calculated maximum power flux density ("PFD") levels within each coverage area and energy dispersal bandwidths, if any, needed for compliance with section 25.208. This information is provided in Schedule S, Table S8 of this Application and in Part III.DD below.

J. § 25.114(c)(10) Estimated Operational Lifetime

Karousel calculates that the satellites in its system will operate for 15 years. At the end of operational life, Karousel plans to relocate its satellites to a disposal orbit, as described in more detail in its narrative response regarding compliance with section 25.114(d)(14).

K. § 25.114(c)(11) Common Carrier Status

Karousel will operate on a non-common carrier basis.

L. § 25.114(d)(1) System Facilities, Operations and Services and How Uplink Frequency Bands Connect to Downlink Frequency Bands

1. System Facilities, Operations, and Services

Section 25.114(d)(1) requires that applicants provide an overall description of system facilities, operations and services and an explanation of how uplink frequency bands would be connected to downlink frequency bands.

As described in the Public Interest Statement,[43] Karousel seeks to offer the world's first space-based, high-capacity data delivery system combined with high-capacity local storage capable of storing terabytes of video content. This system will allow Karousel to offer a robust content catalogue even without a broadband connection. Karousel's satellites will regularly deliver content to Karousel UE, which will locally store the content and allow consumers to access the programming or data whenever they like. A subset of Karousel UE will incorporate uplink capabilities to permit consumers without a broadband connection to communicate with the Karousel head-end facilities. Due to the non-stationary nature of the satellite, the antenna used would be capable of tracking the satellites' motion. The reception system would incorporate block converters, tuners and processors, random access memory, and a small solid-state drive for rapid storage will collect the transmitted content. Longer term storage of the

[43] *See supra* Part II.C.

content retrieved from the exterior antenna will be accomplished via a traditional multi-terabyte hard drive.

The interior unit will have Ethernet communications ports and, in some cases, Wi-Fi to permit connectivity to the user's local area network where one is available. Users will access the video and other content provided by Karousel and stored on UE through an interactive Karousel app running on the Karousel UE or on third-party devices, such as media streaming boxes, smartphones, and tablets.

Karousel plans to provide residential video and data delivery as well as government and commercial enterprise data delivery services to users throughout the United States and abroad.

a) NGSO System Constellation and Coverage

Karousel is a system designed to provide non-real-time delivery of data content (video, audio, cached Internet files, etc.) by way of a High Earth Orbit ("HEO") satellite utilizing a highly inclined, elliptical geosynchronous orbit.

As opposed to a geostationary orbit that is fixed in a band around the equator, a geosynchronous orbit is inclined relative to the equatorial plane of the Earth. Although satellites in both geostationary and geosynchronous orbits match the rotation of the Earth (*i.e.*, both orbit the Earth in one sidereal day), geostationary satellites remain fixed in the sky relative to Earth while geosynchronous satellites move between the northern and southern hemispheres and east and west in a closed "figure eight" track.[44] Thus, geosynchronous orbits allow a satellite to remain over one part of the world for a significant portion of its orbital period. While this orbit is not as well known as the equatorial plane geostationary orbit, it is nonetheless a well-

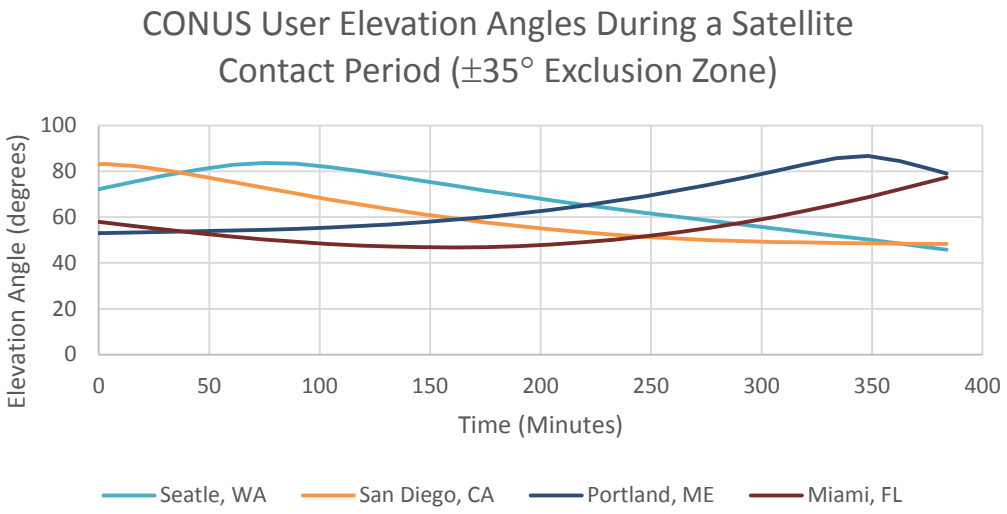
[44] A geostationary orbit is a specific type of geosynchronous orbit in which the satellite is located over the equator.

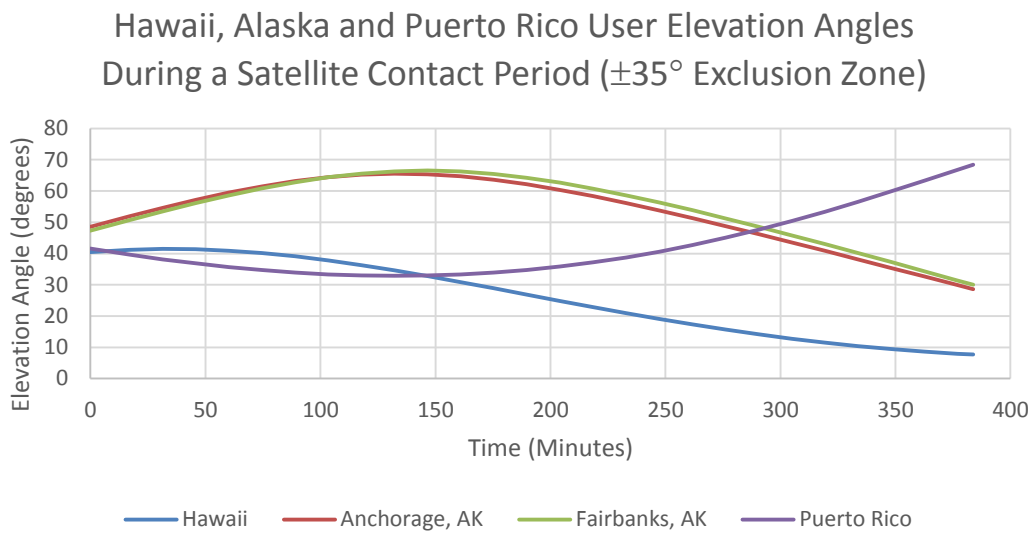
understood orbit that has been used in commercial operations. For example, a variation of this orbit is used by Sirius Satellite Radio to provide satellite radio services across the United States and Canada.

The "figure eight" track of the highly inclined, elliptical, geosynchronous orbit offers high elevation coverage of regions on both sides of the equator. Such an orbit provides full coverage to the intended area, but each satellite is only visible (and therefore only provides service) to any point in the coverage area for six-to-eight hours per day. With additional satellites in similar orbits, a four-satellite constellation can provide 24-hour coverage to a portion of the world.[45]

Another benefit of using the inclined elliptical geosynchronous orbit is that it typically offers high elevation look angles to the ground-based user. The high elevation angle greatly reduces the potential for signal blockage caused by local clutter. As shown in the figures below, elevation angles in the continental U.S. are usually well above 50 degrees for most of each satellite's transmission time. In Alaska and Puerto Rico elevation angles are typically well above 30 degrees, while in Hawaii the elevation angle is as high as 40 degrees and above 20 degrees about 60 percent of the time.

[45] Due to the non-real-time nature of its content delivery system, the Karousel service can function with less than 24-hour coverage; therefore, service may be initiated before all four satellites are on line.





While the initial focus is providing service over the Americas, the same concept will be used to launch additional satellite constellations to cover Europe/Africa and Asia/Australia thereby expanding coverage to most major markets. The ground track of Karousel's twelve proposed satellites is shown the figure in Part III.G.

The system is designed to operate using two gigahertz of Ku-band spectrum and two gigahertz of Ka-band spectrum for downlink to users, and an additional 500 MHz of Ku-band spectrum for uplinks from users. Feeder links can provide sufficient data to the satellite using a

smaller amount of spectrum of three gigahertz; this efficiency is attributable to frequency reuse among feeder links from more than one gateway location. Another 500 megahertz of Ka-band spectrum will complete the return link between the satellites and the gateway; however, the two 500 megahertz bands to be used for the return links (*i.e.*, the user-to-satellite links and the satellite-to-gateway links) will be shared with the forward links on an as-needed basis transponder-by-transponder. Thus, the system will require seven gigahertz of spectrum in total.

The satellites envisioned will be 18 to 25 kW class satellites. The satellites will be configured with thirty-two 2x170 Watt transponders. Each transponder will cover 250 MHz of spectrum with half transmitting in RHCP polarity and half in LHCP. This effectively doubles the amount of spectrum available to the satellite, since each polarization can use the same frequency to send different content on a non-interfering basis.

Karousel plans to use Digital Video Broadcasting ("DVB") standards throughout the Karousel system where they apply, in order to leverage existing technology and minimize development and device costs. Direct-to-Home ("DTH") satellite TV operators commonly use this modulation standard. Leveraging this standard maximizes the likelihood that inexpensive Commercial Off-The-Shelf ("COTS") chipsets will be available for use in the user terminal, and that there is no significant technology development needed on the satellite or in the gateway.

One satellite can initiate service and can offer up to 8 Gbps of downlink data rate. Over a single, six-hour period of visibility, the delivered payload from one satellite would exceed 21 terabytes. Put in perspective, 21 terabytes is roughly the equivalent of 12,000 hours of HD video deliverable per day.

As discussed above, additional satellites would increase the coverage time to a complete 24 hours. Therefore, a four-satellite system would provide daily carousel capacity of more than

84 terabytes. Since the coverage is non-constant, a special method is required to assure error-free delivery of the data files to the end user. Again, the satellite system will take advantage of a protocol developed as part of the DVB standard: the data carousel. A data carousel is an efficient means to deliver data such as video content to multiple users. It is particularly useful in one-way systems in which the transmitter does not receive feedback from the receiver regarding transmission errors. A software carousel is not unlike the common amusement ride for which they are named, as they virtually "spin" and deliver data in a continuous cycle. For example, in the Karousel system, each video or other file type will be broken down into blocks of encoded data that are then arranged around the edge of the virtual carousel. A single carousel may be loaded with multiple videos or other files that users may wish to download from the satellite. The carousel then spins such that each block of data enters the satellite transmission stream in sequence. When the last block has entered the transmission stream, the carousel repeats the delivery process. The carousel receivers in the UE can be programmed by the user to receive specific content, and the receiver will monitor the data being delivered by the carousel until it identifies the desired content. At this point, the content will be delivered to the receiver; however, due to normal propagation effects, some errors in the transmission may occur. More than one round of the carousel may be needed for the receiver to successfully receive enough blocks to reconstruct the desired file or files. Due to the encoding, each file can be reconstructed from a subset of the blocks that originally comprised it.[46] When the receiver has successfully received enough blocks to reconstruct the entire file, it will stop downloading from the carousel,

[46] As an example, Raptor coding as used in the blocks inserts redundancy in each block. Normally, the size of all the blocks sent is up to 30 percent larger than the base file. Because of this enlargement, the blocks do not need to be received in order and only 70 to 80 percent of the total block count needs to be received in order to reconstitute the original file.

reconstruct the file, and forward the complete content to the storage device in the UE. The user can then view the content at his convenience.

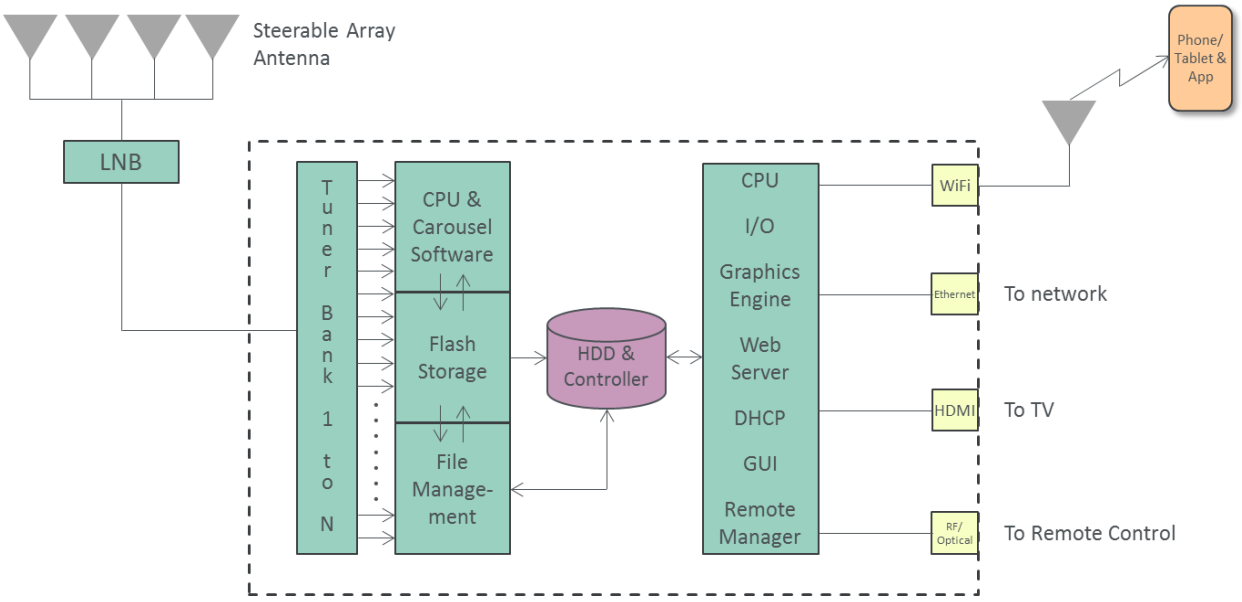
b) Global Broadband Terminals and Services

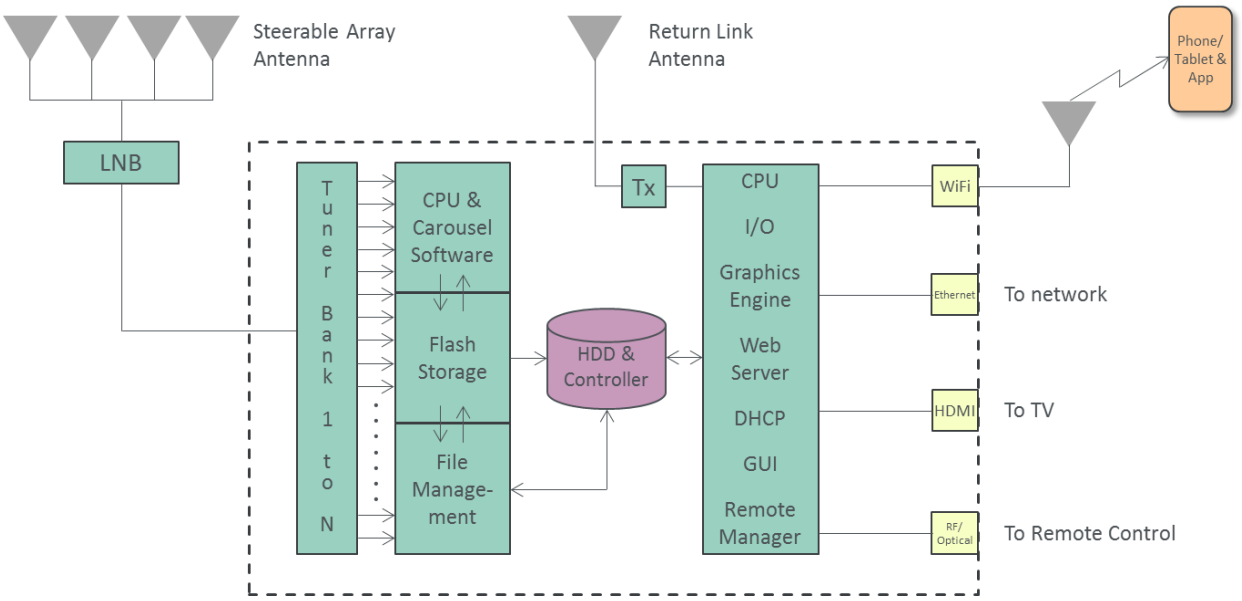
The UE will leverage COTS chipsets where possible. In addition to the tuner and chipsets, the user terminal will include both solid state disk and hard disk drive storage devices and a microprocessor to implement the carousel receiver and to provide a user interface for interaction with the UE and access to the stored content.

The antenna will be a small (45 cm to 75 cm class) parabolic or flat planar antenna designed to be mounted flat on a rooftop, awning, or on a vehicle. At its simplest and least expensive, this antenna would be a single-polarization, single-band wide-aperture device that would be pointed to maximize the visibility of the satellite based on the location of the user. While this implementation would lessen the available time the satellite was visible, it would cost far less and open the market place to a greater number of price sensitive users.

On the high cost end, this antenna would be a dual polarization self-aiming adaptive array antenna that would "follow" the satellite through its figure-eight orbital path, and be able to receive content from both polarizations and multiple transponders simultaneously. The bitrate from each satellite is expected to be up to 8 Gbps per second.

The diagrams below depict two potential UE designs. The first diagram shows a model that does not have return-channel capability. (A user of this model would rely on the Ethernet port or Wi-Fi for return-link connectivity over the Internet, if a return link were required.) The second diagram shows a model with a return-channel antenna. Different users would deploy different models depending on the conditions and applications.





2. System Frequency Usage and Frequency Plan

Karousel is providing the uplink and downlink frequency plans for the NGSO System in narrative and in Table S2 of Schedule S. The channels associated with these frequency bands are described in Table S9 of Schedule S. The figures below summarize the frequencies for which

Karousel seeks authority to use for operation of its system and depicts the other U.S. allocations in the relevant bands.

Karousel Service Links

Band (GHz)	Sub Band (GHz)	Link	FSS Non-Federal U.S. Allocation for NGSO	Other U.S. Allocations *
10.7-12.7	10.7-11.7	Downlink	Primary (space-to-Earth) [gateway only]	FIXED, FSS (space-to-Earth)
	11.7-12.2		Primary (space-to-Earth)	FSS (space-to-Earth)
	12.2-12.7		Primary (space-to-Earth) [per 5.487A]	BSS, FIXED
17.8-19.3	17.8-18.3		none (per the FCC Ka band plan)	FIXED, FSS (space-to-Earth)
	18.3-18.6		none (per the FCC Ka band plan)	FSS (space-to-Earth)
	18.6-18.8		none (per the FCC Ka band plan)	FSS (space-to-Earth), Earth Exploration Satellite (passive), Space Research (passive)
	18.8-19.3		Primary (space-to-Earth)	FSS (space-to-Earth)
19.7-20.2	19.7-20.2		none (per the FCC Ka band plan)	MSS (space-to-Earth), FSS (space-to-Earth)

Band (GHz)	Sub Band (GHz)	Link	FSS Non-Federal U.S. Allocation for NGSO	Other U.S. Allocations *
14.0-14.5	14.0-14.2	Uplink	Primary (Earth-to-space)	FSS (Earth-to-space), mss (Earth-to-space), Space research
	14.0-14.4		Primary (Earth-to-space)	FSS (Earth-to-space), mss (Earth-to-space)
	14.4-14.47		Primary (Earth-to-space)	FSS (Earth-to-space), mss (Earth-to-space), Fixed, Mobile
	14.47-14.5		Primary (Earth-to-space) [with limitations]	FSS (Earth-to-space), mss (Earth-to-space), Fixed, Mobile

Karousel Gateway Links

Band (GHz)	Sub Band (GHz)	Link	FSS Non-Federal U.S. Allocation for NGSO	Other U.S. Allocations *
19.7-20.2	19.7-20.2	Downlink	none (per the FCC Ka band plan)	MSS (space-to-Earth), FSS (space-to-Earth)

Band (GHz)	Sub Band (GHz)	Link	FSS Non-Federal U.S. Allocation for NGSO	Other U.S. Allocations *
14.0-14.5	14.0-14.2	Uplink	Primary (Earth-to-space)	FSS (Earth-to-space), mss (Earth-to-space), Space research
	14.0-14.4		Primary (Earth-to-space)	FSS (Earth-to-space), mss (Earth-to-space)
	14.4-14.47		Primary (Earth-to-space)	FSS (Earth-to-space), mss (Earth-to-space), Fixed, Mobile
	14.47-14.5		Primary (Earth-to-space) [with limitations]	FSS (Earth-to-space), mss (Earth-to-space), Fixed, Mobile
27.5-30.0	27.5-28.35		Secondary (Earth-to-space) [per §25.202, note 7]	FIXED, MOBILE, FSS (Earth-to-space)
	28.35-28.6		Secondary (Earth-to-space) [per §25.202, note 2]	FIXED, MOBILE, FSS (Earth-to-space)
	28.6-29.1		Primary (Earth-to-space) [per §25.202, note 3]	FIXED, MOBILE, FSS (Earth-to-space)
	29.1-29.25		Secondary (Earth-to-space) [per §25.202, note 4]	FIXED, MOBILE, FSS (Earth-to-space)
	29.25-29.5		Secondary (Earth-to-space) [per §25.202, note 5]	FIXED, MOBILE, FSS (Earth-to-space)
	29.5-30.0		Secondary (Earth-to-space) [per §25.202, note 2]	MSS (Earth-to-space), FSS (Earth-to-space) [GSO]

*** Key:**

Red Font	Federal
Green Font	Non-Federal
Black Font	Federal and Non-Federal
UPPER CASE	Primary alllocation
Lower Case	Secondary allocation

As shown above, Karousel generally seeks access to frequencies allocated in the United States on a primary or co-primary basis to non-Federal FSS. For those bands where a primary FSS allocation is unavailable in the United States, such as the 17.8-18.8 GHz band or the 19.7-20.2 GHz band, or where only a secondary FSS allocation exists, such as the 27.5-28.6 GHz and 29.1-

30.0 GHz bands, Karousel seeks the requisite waiver or makes the showing that operations will be conducted on a non-interference basis in this application.

M. § 25.114(d)(6) Public Interest Considerations

Public interest considerations supporting the grant of this Application appear in Part II of this Application.

N. § 25.114(d)(12) NGSO FSS Operators in the 10.7-14.5 GHz Bands

Section 25.114(d)(12) requires applications for authorizations in the NGSO FSS in the 10.7–14.5 GHz bands to provide all information specified in section 25.146. Karousel provides the information required by section 25.146 in Parts III.Q, R, S, T, and U below.

O. § 25.114(d)(14) Mitigation of Orbital Debris (including § 25.283)

The NGSO system would employ the following design and operational strategies to mitigate orbital debris.

1. Control of Debris Released During Normal Operations

The NGSO system would use satellites that generate no debris during deployment and would not generate any debris during normal operation in compliance with the U.S. Government Orbital Debris Mitigation Standard Practices (objective 1-1), which dictates that there will be no release of debris larger than 5 millimeters in any dimension that remains on orbit for more than 25 years. In addition, the satellites would not use exterior materials or designs that may generate debris due to environmental factors (*e.g.*, radiation degradation, thermal fatigue, etc.).

Karousel has assessed and intends to limit the probability of the proposed NGSO satellites becoming a source of debris due to collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal by employing standard debris-shielding techniques, including bumper shields, debris blankets, and redundancy for vulnerable and critical spacecraft elements.

2. Minimizing Debris Generated by Accidental Explosions

To minimize risk of accidental explosions during mission operations, and to ensure that any debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft, on-board storage of energy in the satellites would be limited to:

- Lithium-ion batteries;
- Momentum and reaction wheel assemblies;
- Pressurized fuel tank;
- Constant-conductance heat pipes; and
- Pumped-fluid thermal control systems.

The batteries, momentum, reaction wheel assemblies, and pressurized fuel tank would operate safely within regulated and specified conditions and without risk of environmental-induced failures (*e.g.*, debris damage, radiation degradation, damage from electrostatic discharge events, etc.). The constant-conductance heat pipes would be standard space-qualified designs, which contain low pressure ammonia working fluids that are not conducive to explosions when damaged and have had no prior explosive incidents on-orbit. The pumped-fluid thermal control system would operate at a lower pressure than the heat pipes and has a correspondingly lower risk.

Following completion of mission operations and successful transfer of the satellites into a disposal orbit, passivation of the on-board sources of stored energy would be performed to limit the risk of accidental explosions. This process may include the full discharge and depletion of the batteries, deactivation of the pump fluid system, and de-spinning of the momentum and reaction wheel assemblies. Depletion burns at the end-of-life would be required to ensure that all residual propellant has been eliminated and that the fuel tank would be completely depressurized with subsequent venting.

3. Selection of Safe Flight Profile and Operational Configuration

Karousel is contracting with standard, proven satellite and launch vehicle providers, which have vast experience in ensuring safe mission and compatibility of designs for all phases of construction, launch, and operation of the Karousel satellites and their launch vehicles. Karousel, through its contractors, will routinely assess and limit the probability of its satellites becoming a source of debris by collisions with large debris or other operational space stations through detailed mission planning and operational monitoring.[47]

4. Post-Mission Disposal of Space Structures

Disposal of the satellites would be performed with propulsion. Sufficient propellant will be allocated to dispose of Karousel's satellites in accordance with industry standards and international guidelines to a disposal orbit that will have a planned minimum perigee well above the geostationary arc.[48]

Karousel's contractors will employ standard design practices that would provide sufficient redundancy to ensure a high reliability of successful disposal for all satellites at completion of mission or in the event of individual spacecraft element failure. The proposed disposal orbit altitude will comply with the altitude resulting from application of the Inter-Agency Space Debris Coordination Committee ("IADC") formula expressed as follows:

36,021 km + (1000 × CR × Area/mass) = disposal altitude in km, where

Area of the satellite (average aspect area) is in m^2
Mass of the spacecraft is in kg
CR (solar radiation pressure coefficient)

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[47] 47 C.F.R. § 25.114(d)(14)(iii).

[48] 47 C.F.R. § 25.283(a); *see also* Inter-Agency Space Debris Coordination Committee, IADC Space Debris Mitigation Guidelines, § 5.3 (2007); *Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd. 11567, 11578 ¶ 21 (2004).

Accordingly, Karousel's planned disposal orbit will comply with the Commission's rules.[49]

P. § 25.139 NGSO FSS Coordination and Information Sharing Between MVDDS Licensees in the 12.2 GHz to 12.7 GHz Band

Section 25.139 sets out specific procedures NGSO FSS licensees must follow to allow coordination and information sharing with Multichannel Video and Data Distribution Service ("MVDDS") licensees in the 12.2-12.7 GHz band. Karousel commits to comply with the Commission's required procedures.

Q. §§ 25.145 and 25.146 Geographic Coverage Licensing Provisions

Because of the use of highly inclined orbits, the Karousel satellites can have visibility of all parts of the Earth's surface when deployed in at least three groupings and, therefore, have the ability to provide service to anywhere on Earth subject to the design and positioning of the broadcast beams. Every point on the Earth's surface can see at least one Karousel satellite at all times.

The Commission's geographic coverage requirements are set forth in section 25.145(c)(1) and (2) for Ka-band and section 25.146(i)(1) and (2) for Ku-band. They are essentially the same for both frequency bands and can be summarized as follows:

(1) A demonstration that the proposed system is capable of providing fixed-satellite services on a continuous basis throughout the fifty states, Puerto Rico and the U.S. Virgin Islands, U.S.; and

(2) A demonstration that the proposed system is capable of providing Fixed-Satellite Services to all locations as far north as 70° North Latitude and as far south as 55° South Latitude for at least 75 percent of every 24-hour period.

The Karousel system's twelve operational satellites meet this more precisely defined requirement as explained below.

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[49] *See id.*; 47 C.F.R. §§ 25.114(d)(14); 25.283; *see generally Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd. 11567 (2004).

Ku-Band and Ka-Band Geographic Coverage

For the Ku-band and Ka-band downlinks, the combination of the geographic coverage achievable from each satellite plus the number and proximity of the satellites in their orbits, ensures that blanket global Ku-band coverage is provided by the Karousel constellation. To comply with the EPFD limits and thereby protect GSO satellite networks from interference, the operation of the Karousel satellites is muted when within a proximity of 35 degrees in latitude from the equator. This technique also protects the Karousel system from interference caused by GSO networks.[50]

Gateway Geographic Coverage

The gateway links of the Karousel system provide the necessary communications links to and from the Karousel satellites to provide the service. Karousel intends to install sufficient gateway sites around the world to ensure that the Karousel satellites have a visible gateway earth station with which they can communicate from all parts of their orbits. Therefore, the Karousel Ka-band gateway links will be sufficient to serve Karousel satellites at all latitudes, which meets the requirements of sections 25.145(c)(1) and (2) as far as these rules can be applied to such types of links.

R. § 25.146(a)-(b) Licensing and Operating Rules for NGSO FSS Operators in the 10.7–14.5 GHz Bands; § 25.208 Equivalent Power Flux Density Limits

Section 25.146(a) requires non-geostationary satellite orbit applicants in the 10.7-14.5 GHz bands to provide a comprehensive technical showing demonstrating the NGSO FSS system would not exceed the validation EPFD limits as specified in Section 25.208. The Karousel

[50] By these means, when there are four satellites in the constellation, the full Karousel service is provided to the fifty U.S. states, Puerto Rico, and the U.S. Virgin Islands, so compliance with section 25.146(i)(1) is achieved.

NGSO satellite system has been designed to provide the necessary interference protection to GSO satellite networks in the Ku-band according to the requirements in section 25.146 of the Commission's rules.[51] Karousel also intends to also comply with the additional Ku-band, Ka-band and $EPFD_{is}$ regulations as required under Article 22 of the ITU Radio Regulations that are not expressly referenced in section 25.146 of the Commission's rules.

The frequency ranges used by Karousel to which EPFD limits apply either through the ITU Radio Regulations or the Commission's Part 25 rules are as follows:

Band Name	Frequency Range
Ku-band downlink	10.7-12.7 GHz
Ku-band uplink	14.0-14.5 GHz
Ka-band downlink	17.8-18.6 GHz 19.7-20.2 GHz
Ka-band uplink	27.5-28.6 GHz 29.5-30 GHz

The explanation of Karousel's techniques for complying with the EPFD limits is provided below. These techniques are used both to protect GSO satellite networks against interference from the Karousel NGSO system and to protect the Karousel NGSO system against inference from GSO satellite networks. Karousel protects against harmful interference by ensuring sufficient antenna discrimination isolation from inline and near-inline events between (i) the Karousel NGSO constellation and GSO constellations, and (ii) the PFD levels resulting from positioning of the Karousel NGSO satellite beams.

Attachment 2 provides a detailed explanation of the EPFD levels produced by the Karousel system in Ku-band and how those levels comply with the single-entry EPFD validation

[51] The Commission has not adopted rules similar to section 25.146 for the Ka-band.

limits that appear in sections 25.146(a)(1) and 25.146(a)(2) of the Commission's rules. These EPFD limits exist across both the FSS and BSS portions of the Ku-band, with evaluation using their associated ITU-R antenna discrimination models. The frequencies for the corresponding FSS and BSS allocations across the three ITU Regions of the world vary within the 10.7-12.7 GHz downlink band that Karousel has proposed to use. Karousel complies with both the FSS and BSS EPFD limits.

Compliance with the EPFD limits for the protection of GSO satellite networks by the Karousel NGSO satellite system uplinks and downlinks involves ensuring that sufficient angular separation exists between the transmissions from the Karousel NGSO satellites (in the downlink bands) and user earth stations (in the uplink bands) relative to the potential victim GSO earth stations (in the downlink bands) and satellites (in the uplink bands), respectively. Sufficient separation is primarily accomplished by the operation of the Karousel satellites outside of a +/-35 degree latitude GSO protection zone by having Karousel deploy multiple satellites in geosynchronous altitude orbits providing the same ground track for a given region.

The approach taken by Karousel in this technical showing is to analyze the worst case peak EIRP density values, a worst-case path loss assuming sub-satellite perigee path loss, and a worst case antenna discrimination angles of 20 degrees which does not account for the variation in topocentric angle as viewed from the ground station between the protected GSO arc and the Karousel satellite that is operational outside of the +/-35 degree latitude zone.

The worst-case Ku-band EIRP density is -24.6 dBW/Hz, which corresponds to +21.4 dBW/40 kHz, the evaluation bandwidth. With a worst-case spreading loss of -161.0 dB/m^2, the resulting worst-case PFD in Ku-band from a Karousel satellite is -139.6 dBW/m^2/40 kHz. The worst-case GSO terminal antenna discrimination will occur at the lowest frequency for a given

antenna size; therefore, the evaluation required under section 25.208(g) is made at 10.7 GHz, and the evaluation required under section 25.208(l) is made at 11.7 GHz. Recommendation ITU-R S.1428-1 is used for determining antenna discrimination for evaluation of section 25.208(g), and Recommendation ITU-R BO.1143-1 Annex 1 is used for determining antenna discrimination for evaluation of section 25.208(l). The following tables summarize the compliance of the Karousel satellites to these downlink EPFD requirements for the worst-case temporal exposure (listed as zero percentage of time during which the $EPFD_{down}$ level may not be exceeded):

Rule	**25.208(g) (10.7-12.75 GHz)**			
Reference Antenna Pattern	ITU-R S.1428-1			
Evaluation Frequeny, GHz	10.7			
GSO Termainl Antenna Size, m	0.6	1.2	3	10
Wosrt case EIRP density, dBW/Hz	-24.6	-24.6	-24.6	-24.6
Worst case EIRP density, dBW/40 kHz	21.4	21.4	21.4	21.4
Worst case NGSO range (perigee subsat), km	31570	31570	31570	31570
Worst case spreading loss, dB/m^2	-161.0	-161.0	-161.0	-161.0
Worst case PFD, dBW/m^2	-139.6	-139.6	-139.6	-139.6
Wost case discrimination angle, deg	20	20	20	20
Wosrt case discrimination, dB	37.8	43.9	54.0	64.5
Wost case EPFD, dBW/m^2/40 kHz	-177.4	-183.4	-193.6	-204.0
Requirement, dBW/m^2/40 kHz	-175.4	-181.9	-190.45	-195.45
Wosrt case margin, dB	**2.0**	**1.5**	**3.1**	**8.6**

Rule	**25.208(l) (11.7-12.75 GHz)**							
Reference Antenna Pattern	ITU-R BO.1143-1 Annex 1							
Evaluation Frequeny, GHz	11.7							
GSO Termainl Antenna Size, m	0.3	0.45	0.6	0.9	1.2	1.8	2.4	3.0
Wosrt case EIRP density, dBW/Hz	-24.6	-24.6	-24.6	-24.6	-24.6	-24.6	-24.6	-24.6
Worst case EIRP density, dBW/40 kHz	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4
Worst case NGSO range (perigee subsat), km	31570	31570	31570	31570	31570	31570	31570	31570
Worst case spreading loss, dB/m^2	-161.0	-161.0	-161.0	-161.0	-161.0	-161.0	-161.0	-161.0
Worst case PFD, dBW/m^2	-139.6	-139.6	-139.6	-139.6	-139.6	-139.6	-139.6	-139.6
Wost case discrimination angle, deg	20	20	20	20	20	20	20	20
Wosrt case discrimination, dB	33.0	36.1	38.6	42.1	44.6	48.2	50.7	54.5
Wost case EPFD, dBW/m^2/40 kHz	-172.5	-175.7	-178.2	-181.7	-184.2	-187.7	-190.2	-194.1
Requirement, dBW/m^2/40 kHz	-165.841	-175.441	-176.441	-178.94	-182.44	-184.941	-187.441	-191.941
Wosrt case margin, dB	**6.7**	**0.2**	**1.7**	**2.7**	**1.7**	**2.8**	**2.8**	**2.1**

The tables above show EPFD margin for a single, worst-case Karousel satellite. Typically, only one Karousel satellite will be of concern for any given location. When more than one Karousel satellite is potentially visible from a given location, the contributions from the non-serving Karousel satellites have substantial additional angular antenna discrimination and will not exceed the applicable limits given the conservative assumptions made in these analyses.

Similar to the downlink interference analysis, Karousel took a worst-case approach in analyzing the uplink EPFD into GSO systems. The worst-case Ku-band uplink station EIRP values were assumed for both the gateway uplinks and the multi-terminal return link scenarios, which are mutually exclusive. With a worst-case spreading loss of -162.1 dB/m^2 for GSO stations, the resulting worst-case PFDs in Ku-band to a GSO satellite were calculated. The worst case Karousel NGSO terminal antenna for a given antenna size was then calculated for a worst-case one degree pointing error, which resulted in 19 degrees of antenna discrimination. The evaluation required under section 25.208(k) was made at 14.5 GHz. An additional worst-case assumption was made that all of the Karousel uplink stations were located at the peak of the reference GSO uplink beam, which would provide no antenna discrimination at the GSO satellite. The total number of allowable Karousel uplink terminals was then calculated for both the gateway forward link and user terminal return link scenarios to comply with the -160 dBW/m^2/40 kHz requirement of section 25.208(k) of the Commission's rules. The following table summarizes the compliance of the Karousel satellites to these uplink EPFD requirements:

Rule	**25.208(k) (14.-14.5 GHz)**					
Reference NGSO Uplink Antenna Pattern	ITU-R S.1428-1					
NGSO Uplink Condition	13m GW	7m GW	45cm UT, nom	45cm UT, worst	75cm UT, nom	75cm UT, worst
Evaluation Frequeny, GHz	14.5	14.5	14.5	14.5	14.5	14.5
NGSO system input power, dBW	26.0	26.0	-13.0	-3.0	-13.0	-3.0
NGSO uplink antenna size, m	13	7	0.45	0.45	0.75	0.75
Antenna gain, dBi	64.0	58.7	34.8	34.8	39.3	39.3
EIRP per terminal, dBW	90.1	84.7	21.8	31.8	26.2	36.2
Worst case GSO range (equatorial subsat), km	35786	35786	35786	35786	35786	35786
Worst case spreading loss, dB/m^2	-162.1	-162.1	-162.1	-162.1	-162.1	-162.1
Transmit bandwidth, MHz	200	200	1.25	1.25	1.25	1.25
PFD, dBW/m^2/Hz	-155.0	-160.4	-201.2	-191.2	-196.8	-186.8
Evaluation bandwidth kHz	40	40	40	40	40	40
PFD, dBW/m^2/40 kHz	-109.0	-114.4	-155.2	-145.2	-150.8	-140.8
Wost case discrimination angle, deg	19.0	19.0	19.0	19.0	19.0	19.0
Wosrt case NGSO uplink antenna discrimination, dB	-68.7	-63.3	-37.4	-37.4	-41.9	-41.9
EPFD, dBW/m^2/40 kHz	-177.7	-177.7	-192.6	-182.6	-192.7	-182.7
EPFD Requirement, dBW/m^2/40 kHz	-160	-160	-160	-160	-160	-160
Margin to requirement	**17.7**	**17.7**	**32.6**	**22.6**	**32.7**	**22.7**
Maximum terminals in uplink user channel, center of GSO reference beam (no discrimination)	59	59	1822	182	1848	185
Maximum terminals in 200 MHz channel	59	59	291448	29145	295709	29571
Typical duty cycle	100%	100%	1.0%	1.0%	1.0%	1.0%
Maximum supported terminals per channel at GSO beam peak (worst case analysis)	**59**	**59**	**29,144,848**	**2,914,485**	**29,570,883**	**2,957,088**

As can be seen in the table above, substantial margin exists for both the gateway (forward link) and user terminal (return link) scenarios. The potential for excess EPFD is further mitigated by a

more realistic distribution of user terminals across a given service area relative to the GSO uplink reference beam. Karousel intends to use additional models, including the model defined in ITU-R S.1503-2, to validate this GSO interference analysis.

Finally, section 25.146(b) requires that, ninety days prior to the initiation of service to the public, the NGSO FSS system licensee shall submit a comprehensive technical showing for the NGSO FSS system in the 10.7-14.5 GHz bands demonstrating that the NGSO FSS system would not exceed the validation EPFD limits as specified in Section 25.208(i), (j), and notes 2 and 3 to Table 1L in Section 25.208(l). Karousel intends to satisfy this requirement when due.

S. § 25.146(e) ITU Obligations for NGSO FSS Systems

Section 25.146(e) provides that an NGSO FSS system licensee operating a system in compliance with the limits specified in sections 25.208(g), (i), (j), (k), (l), and (m) shall be considered as having fulfilled its obligations under ITU Radio Regulations Article 22.2 with respect to any GSO network. However, such NGSO FSS system shall not claim protection from GSO FSS and BSS networks operating in accordance with Part 25 of this chapter and the ITU Radio Regulations.

Karousel will operate its system in compliance with the limits specified in sections 25.208(g), (i), (j), (k), (l), and (m). Karousel will not claim protection from GSO FSS and BSS networks operating in accordance with the Commission's Part 25 rules and the ITU Radio Regulations.

T. § 25.146(f) Coordination Requirements for NGSO FSS Systems in the 10.7-12.75 GHz Bands

Section 25.146(f) provides that coordination will be required between NGSO FSS systems and GSO FSS earth stations in the frequency band 10.7-12.75 when certain threshold

conditions are met. Karousel commits to coordinate with other NGSO and GSO FSS operators in the band as required by the Commission's rules.

The requirement for Karousel to protect earth stations in accordance with section 25.146(f) is -202 dBW/m^2/40 kHz for any percentage of time given that the Karousel altitude is above 2500 kilometers. Based on the maximum Karousel EIRP density of -24.6 dBW/Hz and a worst-case, sub-satellite perigee path loss of -161.0 dB/m^2, the resulting worst case value is -208.6 dBW/m^2/40 kHz, or 6.6 dB below the required EPFD.

Karousel will confirm this analysis with ITU software for examining compliance with EPFD limits set forth in Article 22 of the ITU Radio Regulations to ensure that coordination is not required. In the unlikely event that coordination is required, Karousel is optimistic that it can be concluded in a mutually acceptable manner.

U. § 25.146(g) Operational Power Flux Density, Space-to-Earth Direction, Limits

If granted the authorization sought in this application, Karousel will submit a technical showing for demonstrating that Karousel's system is capable of meeting the applicable limits ninety days prior to the initiation of service to the public, as specified in section 25.208(o).

V. § 25.156(d)(4) Separate Treatment of Feeder Links and Service Links

Karousel is requesting a waiver of this rule section, which is addressed in Part IV of this Application.

W. § 25.156(d)(5) NGSO Versus GSO Systems

Karousel is requesting a waiver of this rule section, which is addressed in Part IV of this Application.

X. § 25.164(b), (f) Construction Milestones

Karousel intends to satisfy the construction milestones for NGSO FSS systems. Section 25.164(b) requires licensees of NGSO systems to "launch the space stations, place them in the assigned orbits, and operate them in accordance with the station authorization no later than six years after the grant of the license." Karousel will demonstrate compliance with this requirement or notify the Commission of an alternative outcome within 15 days after the deadline, as required by Section 25.164(f).

Y. § 25.165 Surety Bonds

Karousel commits to satisfying the Commission's escalating surety bond requirement should it receive a space station authorization. Section 25.165(a)(1) requires NGSO licensees to have on file a surety bond requiring payment in the event of default. Karousel will post a surety bond requiring initial payment in the case of a surrender of its authorization in an amount of at least $1 million within 30 days of grant of its license with payment liability under the bond increasing over a six-year period to a final value of $5 million.[52] Karousel will increase the value of the surety bond over the six-year period following grant of authority to comply with the formula of 25.165(c) of the Commission's rules. For the bond, Karousel will use a surety company deemed acceptable within the meaning of 31 U.S.C. 9304 *et seq*. as required under section 25.165(b) of the Commission's rules.

Z. § 25.202(a)(1) Spectrum Bands Available for FSS

Karousel is requesting authority to launch and operate an NGSO FSS system in the 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-19.3 GHz, 19.7-20.2 GHz, and 27.5-30.0 GHz bands. With the

[52] *Comprehensive Review of Licensing & Operating Rules for Satellite Servs.*, Second Report and Order, 30 FCC Rcd. 14713, 14741 ¶ 70 (2015).

exception of the 17.8-18.3 GHz band for which a waiver is sought, these bands are available for use by non-federal FSS on a primary or, in some cases, secondary basis pursuant to sections 2.106 and 25.202(a)(1) of the Commission's rules.[53]

AA. § 25.202(g) Telemetry, Tracking, and Command Signals

Karousel will provide telemetry, tracking and command transmissions ("TT&C") at the band edge of the assigned bands as required under section 25.202(g)(1) of the Commission's rules. Karousel will select TT&C frequencies, polarization, and coding to minimize interference into other satellite networks consistent with section 25.202(g)(2).

The basic parameters of the overall TT&C system are described in this section and complement the information provided in the associated Schedule S submission. The Karousel TT&C system provides for communications during pre-launch, transfer orbit and on-station operations, as well as during spacecraft emergencies. The TT&C system controls and monitors all aspects of the spacecraft necessary for onboard equipment configuration, safe operations and health monitoring. Some control data is required in real-time (*e.g.*, certain payload control functions), but other data is not as time-sensitive because the spacecraft are sufficiently autonomous for periods of time without receiving continuous telecommand signals. The time-sensitive satellite control information is transmitted to and from the Karousel satellites using the gateway earth stations. All satellite control transmissions to and from these gateway earth stations are at EIRP density levels no higher than the gateway communications carriers because they access the high-gain satellite antennas on-board the Karousel satellites. Because these transmissions may take place from U.S. gateway earth stations, their technical parameters are included in the associated Schedule S.

[53] The 17.8-18.3 GHz band is not allocated to non-federal FSS.

These TT&C earth stations can also communicate with the Karousel satellites via the low-gain, near-omnidirectional TT&C antennas on the Karousel satellites.

A summary of the TT&C are given in the table below. The frequency ranges specified for the TT&C transmissions may be reduced further as the final operational TT&C frequencies are selected, and Karousel will inform the Commission of this at that time.

TT&C Characteristics	
Uplink Control Signal Modulation	PSK/PCM/FM
Uplink Control Frequencies	14000 – 14005, 14495 – 14500 MHz 29500 – 29505, 29495 – 29500 MHz
Downlink Control Signal Modulation	PCM/BPSK
Downlink Control Frequencies	11700 – 11705, 12195 – 12200 MHz 19700 – 19705, 20195 – 20200 MHz
Polarization of Satellite Rx/Tx Antennas	Rx: LHCP & RHCP Tx: LHCP & RHCP

BB. § 25.204(e) Uplink Adaptive Power Control

All Karousel gateway and user uplink stations will incorporate uplink adaptive power control to minimize potential interference. Earth station transmissions under conditions of uplink fading will utilize power control methods to not exceed 1 dB above the actual uplink excess attenuation over clear-sky conditions, as required by section 25.204(e).

CC. § 25.207 Cessation of Emissions

Section 25.207 requires that space stations shall be made capable of ceasing radio emissions by the use of appropriate devices (battery life, timing devices, ground command, and related functionalities) that will ensure definite cessation of emissions. Karousel is contracting

with leading engineers to develop equipment capable of complying with this requirement, and commits to comply with this requirement. As a minimum, each active Karousel satellite transmission chain (channel amplifiers and associated travelling-wave tube amplifiers ("TWTAs")) can be individually turned on and off by ground telecommand and/or automated on-board timing commands, thereby causing cessation of emissions from the satellite, as required by 25.207 of the Commission's rules.

DD. § 25.208 Power Flux Density Limits

Sections 25.208(b)-(e) provide specific power flux density limits for various bands proposed for operations in Karousel's system. Karousel commits to comply with these limitations. As provided in section 25.146(e), an NGSO FSS system licensee operating a system in compliance with the limits specified in sections 25.208(g), (i), (j), (k), (l), and (m) shall be considered as having fulfilled its obligations under ITU Radio Regulations Article 22.2 with respect to any GSO network. However, such NGSO FSS system shall not claim protection from GSO FSS and BSS networks operating in accordance with Part 25 of this chapter and the ITU Radio Regulations.

As indicated in Table S8, the NGSO System would comply with the PFD limits specified in sections 25.208(b) and 25.208(c), (d), (e), and 25.208(o) of the Commission's rules for NGSO FSS satellite systems operating in the 10.7-11.7 GHz, 18.3-18.8 GHz, and 12.2-12.7 GHz bands, respectively.

The maximum Ku-band PFD for a Karousel satellite at any elevation angle on the visible Earth using the shortest path during the orbit is -150 dBW/m^2 in 4 kHz (-126 dBW/m^2 in 1 MHz) for the 10.7-12.7 GHz band. This is compliant for all cases and requirements in section 25.208(b).

The maximum Ka-band PFD for a Karousel satellite at any elevation angle on the visible Earth using the shortest path during the orbit is -126 dBW/m2 in 1 MHz for the 17.8-19.3 and 19.7-20.2 GHz bands. For the 18.6-18.8 GHz band, the maximum PFD in 200 MHz is -101 dBW/m^2. This is compliant for all cases and requirements in sections 25.208(c), 25.208(d) and 25.208(e).

The Commission has specific low-elevation PFD limits in section 25.208(o) which apply in the 12.2-12.7 GHz band to protect the MVDDS service. These limits, which relate to the PFD into an actual operational MVDDS receiver, are defined as follows:

- -158 dB(W/m^2) in any 4 kHz band for angles of arrival between 0 and 2 degrees above the horizontal plane;
- -158+3.33(δ -2) dB(W/m^2) in any 4 kHz band for angles of arrival δ (in degrees) between 2 and 5 degrees above the horizontal plane.

Compliance with the Commission's low elevation PFD limits of section 25.208(o) to protect the MVDDS service in the 12.2-12.7 GHz band can be achieved assuming only a 8 dB reduction in the worst-case maximum EIRP density transmitted towards low elevation directions. For the primary UD1A and UD1B downlink beams, there is substantially more rolloff than 8 dB as indicated in the associated gain patterns for the nominal pattern positioning over the United States. If these beams, or any of the other downlink beams, are operated near the edge of the visible Earth where elevation angles below 5 degrees would result, the transponder power levels for channels in the 12.2-12.7 GHz band would be reduced as necessary to meet the requirements of this section. Therefore, in practice the Karousel satellite downlinks will achieve compliance with the Commission's low-elevation PFD limits, typically with substantial margin.

EE. § 25.210(f) Frequency Reuse

Section 25.210(f) requires that all FSS space stations shall employ state-of-the-art full frequency reuse. Karousel understands the requirement. For each Karousel satellite grouping, the frequency re-use achieved will be as follows:

(1) In Ku-band, at least four-times spatial frequency re-use is achieved per satellite group by re-using the same Ku-band frequencies between geographically separated beams from at least two different satellites, and two-times polarization frequency re-use is achieved per satellite with each orthogonal circular polarization;

(2) In Ka-band, up to eight-times spatial frequency re-use is achieved per satellite group by re-using the same Ka-band frequencies between geographically separated beams from at least two different satellites, from up to two different gateway uplink locations, and two-times polarization frequency re-use is achieved per satellite with each orthogonal circular polarization.

Beyond these levels, Karousel is contracting with leading engineers to develop innovative and even more efficient frequency reuse operational plans consistent with the nature of this service.

FF. § 25.261 Coordination Procedures

Section 25.261 requires that non-Federal-Government NGSO FSS satellite networks operating in the 28.6-29.1 or 18.8-19.3 GHz frequency bands to "coordinate in good faith" and to follow the coordination procedures provided by the Commission's rules and guidance.[54] Karousel commits to coordinate in good faith with other authorized users in these bands.

GG. § 25.271(e) Control of Transmitting Stations

Section 25.271(e) requires that the licensee of an NGSO FSS system operating in the 10.7–14.5 GHz bands shall maintain an electronic web site bulletin board to list the satellite ephemeris data, for each satellite in the constellation, using the North American Aerospace

[54] *International Bureau Provides Guidance Concerning Avoidance of In-Line Interference Events Among Ku-Band NGSO FSS Systems*, Public Notice, 30 FCC Rcd. 11534 (IB Oct. 20, 2015).

Defense Command ("NORAD") two-line orbital element format. The orbital elements shall be updated at least once every three days. Karousel will comply with this requirement.

IV. REQUESTED WAIVERS

A. Waiver of Certain Footnotes and Limitations of §§ 2.106 and 25.202(a)(1)

Sections 2.106 and 25.202(a)(1) of the Commission's rules identify the spectrum allocations that are available for use by FSS systems in the United States. Karousel is requesting authority to operate its system the 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-19.3 GHz, 19.7-20.2 GHz, 27.5-30.0 GHz bands. Karousel requests a waiver of portions of sections 2.106 and 25.202(a)(1) for a subset of the bands requested.

The Commission has waived sections 2.106 and 25.202(a)(1) of its rules "when there is little potential interference into any service authorized under the Table of Allocations and when the non-conforming operator accepts any interference from authorized services."[55] Karousel has conducted an interference analysis for its proposed operations in the bands for which waiver is requested and has concluded that its proposed operations will not interfere with other authorized users. Karousel will accept interference into its system from any such authorized user. Karousel's proposed operations in each band would not undermine the policy objective of the Commission's rule and would serve the public interest.[56]

By authorizing Karousel to use these bands consistent with the limitations specified below, Karousel can offer an innovative, low-cost data-delivery option for residential and

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[55] *See, e.g., L-3 Commc'ns Titan Corp*., 24 FCC Rcd. 3047, 3049–50 ¶ 9 (2009) (citing Fugro-Chance, Inc., *Order and Authorization*, 10 FCC Rcd 2860 (Int'l Bur. 1995) (authorizing operations of receive-only mobile earth terminals in the 11.7-12.2 GHz band on a non-interference basis)).

[56] *See Applications by Orbcomm License Corp.,* Order and Authorization, 23 FCC Rcd. 4804, 4809 (2008); *see also Qualcomm, Inc.*, Memorandum Opinion, Order, and Authorization, 4 FCC Rcd. 1543 ¶ 11 (1989).

enterprise users alike. The system will also introduce new competition into the video distribution marketplace, which will deliver cost savings to consumers and providing a new platform for programmers and alternative video distributors to reach new audiences.

1. 10.7-11.7 GHz

Karousel requests a waiver of footnote NG52 in the 10.7-11.7 GHz non-Federal allocation in of section 25.202 of the Commission's rules to permit the use of the 10.7-11.7 GHz band for downlink satellite transmissions other than transmissions to or from gateway earth stations. The 10.7-11.7 GHz band is allocated for fixed, fixed-satellite (space-to-earth), and mobile uses, and operations are currently limited to transmissions to or from gateway earth stations.[57]

The 10.7-11.7 GHz band was reserved for international systems, but the Commission has opened the band to alternative uses over the past decade. In 2005, the Commission opened a portion of the band (10.95-11.2 GHz and 11.45-11.7 GHz) to use for satellite earth stations on vessels ("ESVs").[58] Previously, such uses had been authorized by grant of Special Temporary Authority, but the Commission amended its rules to authorize ESVs to communicate with U.S. earth stations through space stations of the FSS, and required that ESVs adhere to power limits and accept interference from terrestrial systems operating in accordance with Commission rules.[59] The Commission reasoned its amendments would "ensure expeditious processing and regulatory certainty."[60] In 2009, the Commission further opened the band to communications by

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[57] 47 C.F.R. § 25.202(a) n.6.

[58] Procedures To Govern the Use of Satellite Earth Stations on Board Vessels in the 5925-6425 MHz/3700-4200 MHz Bands and 14.0-14.5 GHz/11.7-12.2 GHz Bands, 70 FR 4775-01 (2005).

[59] *Id.* at NG 182.

[60] *Id.* at 4776.

vehicle-mounted earth stations ("VMES") with GSO FSS space stations, provided that operators accept interference from fixed service stations.[61] In 2013, the Commission again opened the band, this time to earth stations aboard aircraft ("ESAA"). The Commission authorized ESAAs for the reception of FSS emissions from geostationary satellites, subject to the condition that these earth stations shall not claim protection from transmissions of non-Federal stations in the fixed service.[62]

In keeping with the Commission's recognition of new and expanding opportunities for NGSO FSS uses in the 10.7-11.7 GHz band, Karousel requests that the Commission grant a limited waiver of portions of sections 2.106 and of section 25.202(a) to permit Karousel to conduct transmissions from the satellite to UE, rather than exclusively from the satellite to gateway earth stations.

Karousel's service will not cause harmful interference to other authorized users in the band and Karousel will coordinate with other authorized FSS operators in this band to avoid any potential for interference. The initial results of the EPFD analysis described in section 25.208(g) as required by section 25.146(a) confirm that Karousel's system will comply with the required $EPFD_{down}$ limits in all cases. Also, consistent with section 25.146(b), Karousel will submit a technical showing demonstrating compliance with the operational EPFDdown limits in sections 25.208(i) and (j) when required and will also comply with the aggregate limits of in section 25.208(h). In addition, Karousel will comply with note US131 which requires NGSO licensees operating in the 10.7-11.7 GHz band to coordinate with radio astronomy facilities operating in

[61] Amendment of the Commission's Rules To Allocate Spectrum and Adopt Service Rules and Procedures To Govern the Use of Vehicle-Mounted Earth Stations in Certain Frequency Bands Allocated to the Fixed-Satellite Service, 74 FR 57092-01 (2009).

[62] Earth Stations Aboard Aircraft Communicating With Fixed-Satellite Service Geostationary-Orbit Space Stations, 78 FR 14920-01 (2013).

the 10.6-10.7 GHz band prior to commencing operations. This coordination will also ensure compliance with the requirements of notes US211 and US74. Furthermore, Karousel will comply with the requirement to coordinate its operations in the 10.7-10.95 GHz and 11.2-11.45 GHz bands with other NGSO licensees as described in note 5.441 and ITU RR No. 9.12.

Karousel's proposal to use the extended Ku-band frequencies to deliver content to consumers is another innovative use of this band; granting a waiver of footnote NG52 in the 10.7-11.7 GHz non-Federal allocation in of section 25.202 would promote the public interest.[63]

2. 17.8-18.8 GHz

Karousel requests that the Commission waive relevant portions of sections 2.106 and 25.202(a) to permit NGSO FSS operations in the 17.8-18.3 GHz and 18.3-18.8 GHz bands. Karousel intends to use the 17.8-18.8 GHz band as part of a larger, contiguous block of spectrum from 17.8 GHz to 19.3 GHz to provide downlink service links.[64] Section 25.202(a) does not provide an authorization for NGSO FSS in the 17.8-18.3 GHz band. Section 2.106 instead allocates the 17.8-18.3 GHz band for the non-federal Fixed Service as well as for federal Fixed Satellite (space-to-Earth) Service. Section 2.106 allocates the 18.3-18.8 GHz bands to non-governmental FSS service, but the Ka-band Plan and NG164 designate the 18.3-18.8 GHz band for GSO FSS. Karousel's service will not cause harmful interference to other authorized users in

[63] The Commission has previously granted waiver of limitations on the 10.7-11.7 GHz band to promote video competition and programming diversity. *See PanAmSat Licensee Corp.*, Order and Authorization, IBFS Nos. SAT-MOD-20050325-00072, SAT-MOD-20050325-00073, SAT-MOD-20050325-00074 (2005) ("Grant of these applications will serve the public interest by enabling PanAmSat to make additional FSS capacity available for U.S. domestic use, including the delivery of high-definition television and local-into-local programming, thereby enhancing consumer choice in space radiocommunication providers and services.").

[64] For a discussion of spectrum-sharing capabilities in this band, see Part V, below.

the bands, and Karousel will coordinate with Federal operators and other authorized FSS operators in these bands to avoid any interference.

17.8-18.3 GHz. The Commission licenses the Fixed Service in the 17.8-18.3 GHz band on a site-by-site basis under Parts 74, 78 and 101 of its rules.[65] In the neighboring 17.7-17.8 GHz and 18.3-18.6 GHz bands, the FCC has adopted a downlink PFD limit based on the angles of arrival above the horizontal plane.[66] The ITU has also adopted a more conservative PFD limit for the entire 17.7-19.3 GHz band, which is identical to the PFD limit the Commission has adopted for the 18.8-19.3 GHz portion of the band.[67]

In a request for a waiver to permit GSO FSS operations in the 17.8-18.3 GHz band, Inmarsat noted that its operations would comply with the PFD limits in the nearby 18.8-19.3 GHz band and, therefore, would not present interference issues for terrestrial operations in the 17.8-18.3 GHz band.[68] Karousel, similarly, intends to use the 17.8-18.3 GHz band in tandem with the 18.3-19.3 GHz band and, as explained elsewhere in this application, will comply with the PFD limits for these bands. The existing PFD limits applicable to Karousel's space stations will adequately protect Fixed Service transmissions from harmful interference from Karousel's downlink operations. Karousel will also coordinate as necessary with any Federal users in this

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[65] *See* 47 C.F.R. § 101.147(a).

[66] *See* 47 C.F.R. § 25.208(c).

[67] *See* 47 C.F.R. § 25.208(e); ITU, Radio Regulations Art. 21 (2016).

[68] *Inmarsat Mobile Networks, Inc. Application to Operate a Fixed-Satellite Service Gateway Earth Station Facility in Lino Lakes, Minnesota with the Inmarsat-5 F2 Space Station*, Order and Authorization and Declaratory Ruling, 30 FCC Rcd. 2770 ¶¶ 23-25 (2015) (granting Inmarsat's Application, including granting a waiver allowing GSO FSS operations in the 17.8-18.3 GHz band).

band, as required by footnote US334 to the U.S. Table of Frequency Allocations.[69] Therefore, Karousel's use of the 17.8-18.3 GHz band would, like the use authorized for Inmarsat, not present interference issues.

18.3-18.8 GHz. Karousel can also operate an NGSO FSS system in the 18.3-18.8 GHz band without causing interference to GSO FSS systems. Unlike the 17.8-18.3 GHz band, section 25.202(a) allows for space-to-Earth FSS service in the 18.3-18.8 GHz band. Non-governmental note 164 to section 2.106 limits use of the 18.3-18.8 GHz spectrum to GSO systems, but the Commission has waived this limitation in the past. For example, the Commission previously granted O3b permission to use the 18.3-18.6 GHz band for NGSO operations on a non-conforming basis and subject to certain conditions designed to protect primary GSO FSS systems.[70] In particular, O3b agreed to observe the ITU's EPFD limit which would protect GSO FSS systems operating in the band.[71] Karousel can observe the same PFD limits to protect

[69] 47 C.F.R. § 2.106, n.US334.

[70] *See* FCC, Radio Station Authorization License Granted to O3b Limited, Call Sign E130021, IBFS File No. SES-LIC-20130124-00089 (June 20, 2013); *see also* FCC, Radio Station Authorization License Granted to O3b Limited, Call Sign E130107, IBFS File No. SES-LIC-20130618-00516 (June 24, 2015) (granting O3b authorization to operate an NGSO FSS earth station within the 18.3-18.6 GHz band); Letter from Jose P. Albuquerque, Chief, Satellite Division, International Bureau, FCC to Suzanne Malloy, Vice President, Regulatory Affairs, O3b Limited, IBFS File No. SEC-MSC-20151021-00760 (Jan. 29, 2016) (waiving the Commission's Ka-band Plan to allow 30 O3b earth stations to communication with NGSO FSS satellites using the 17.8-18.6 GHz frequency band).

[71] *See Ex Parte* Letter from Joslyn Read, Vice-President, Regulatory Affairs, O3b Networks USA LLC to Marlene H. Dortch, Secretary, FCC, IBFS File No. SES-LIC-20130618-00516 at 2 (Jan. 27, 2014) ("O3b demonstrated in its Application how by observing the ITU's EPFD limits it will protect [GSO] FSS systems that have primary status. This protection is facilitated by the inherent angular separation between the O3b and geostationary orbits when viewed from the Earth at latitudes away from the equator. EchoStar took no issue with O3b's showing that it can protect primary GSO FSS systems.").

incumbent GSO FSS systems operating in the band and coordinate its NGSO FSS system with Federal FSS systems in the 17.8-18.8 GHz band.[72]

Karousel will also accept any interference that its user equipment may experience from Fixed Service or GSO FSS transmissions due to Karousel's proposed non-conforming use of the bands. Karousel does not expect to experience any harmful interference, and Karousel can make necessary technical adjustments to power levels and elevation angles to prevent harmful interference to its system from Fixed Service or other primary FSS transmissions. Where necessary, Karousel can use frequency-avoidance measures and limit its operations to the other sub-bands of spectrum within the larger 17.8-19.3 GHz downlink band as may prove necessary to avoid harmful interference.

3. 19.7-20.2 GHz

Karousel requests that the Commission waive relevant portions of sections 2.106, 25.202(a), and 25.103 to permit non-Federal NGSO FSS operations in the 19.7-20.2 GHz band. Section 25.202(a) provides an allocation for GSO FSS in the 19.7-20.2 GHz band, but not NGSO FSS. Section 2.106 allocates the 19.7-20.2 GHz band for primary federal and non-federal FSS and a primary non-federal allocation to MSS, both in the space-to-Earth direction. Consistent with note 5.529, the MSS allocation in Region 2 in most of the band is limited to satellite networks that are in both FSS and MSS. In the United States, section 25.103 designates the 19.7-20.2 GHz band as primary for GSO FSS operations.

Karousel seeks authority to use the 19.7-20.2 GHz band for space-to-earth links from Karousel satellites to both gateways and users on a switchable, as needed basis. Karousel will

[72] Further, Karousel agrees to abide by the EIRP and PFD limits that apply to services operating in the 18.6-18.8 GHz band. *See* 47 C.F.R. § 2.106 US254, US255.

comply with the requirement in US334(a) to coordinate operations with federal FSS systems. Neither the Commission's rules, nor the ITU Radio Regulations include PFD limits for this band; however, ITU RR Table 22-1C includes EPFD limits for 19.7-20.2 GHz. Karousel's initial calculations show that the Karousel system will be able to meet these requirements. Article 22.5I of the ITU Radio Regulations provides that if the associated EPFD limits are met, the NGSO FSS satellite system is considered coordinated with GSO networks. Karousel's operations, therefore, should not affect primary non-federal GSO operations in the band or federal NGSO and GSO operations. Even so, Karousel will coordinate with other authorized non-federal GSO FSS and MSS operators in this band and with authorized federal NGSO and GSO operators to avoid harmful interference to operators with primary designations in this band. Karousel will not claim protection from other authorized operations in the band for its satellites in the 19.7-20.2 GHz band.

The Commission has previously granted non-conforming NGSO operations in the 19.7-20.2 GHz band where there is little potential for interference and the non-conforming operator accepts any interference from authorized services. In 2004, for example, the Commission granted a waiver request to permit non-conforming NGSO operations in the 19.7-20.2 GHz band because the waiver applicant in that case, contactMEO, had demonstrated the operations of its NGSO satellites in the 19.7-20.2 GHz band met the ITU EPFD limits in Article 22, Tables 22-1C and 22-4B.[73] The Commission found that granting the waiver would also serve the public interest by allowing contactMEO to offer consumers a range of broadband and interactive

[73] *contactMEO Communications, LLC for Authority to Launch and Operate a Non-Geostationary Orbit Fixed-Satellite System in the Ka-band Frequencies*, Order and Authorization, 21 FCC Rcd. 4035 ¶¶ 21-27 (IB Apr. 14, 2006).

services.[74] In 2009, the Commission again granted a waiver authorizing NGSO operations in the 19.7-20.2 GHz band when Northrop Grumman made the same type of showing that its operations complied with the ITU EPFD limits in Article 22.[75] There, the Commission similarly found that granting the waiver would serve the public interest by allowing Northrop Grumman to offer consumers a range of broadband and interactive services.[76] Granting a waiver to allow Karousel to operate NGSO satellites in the 19.7-20.2 GHz band will not undermine the objective of the Commission's rule to protect primary services and will serve the public interest by allowing Karousel to offer consumers a range of data and video content delivery services.

B. Temporary Waiver of § 25.146(a)

Section 25.146(a) directs applicants to provide a comprehensive technical showing that "the proposed NGSO FSS system would not exceed the validation equivalent power flux-density (EPFD) limits as specified in section 25.208 (g), (k), and (l) for $EPFD_{down}$, and $EPFD_{up}$." Karousel has provided a detailed technical analysis showing compliance.[77] Because the specific software analysis identified in section 25.146(a) is unavailable, Karousel requests a six-week waiver of section 25.146(a) to permit Karousel to formalize its analysis using the precise modeling tool described in the rules.

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[74] *Id.* ¶ 27.

[75] *Northrop Grumman Space & Mission Systems Corp. Applications for Authority to Operate a Global Satellite System Employing Geostationary Satellite Orbit and Non-Geostationary Satellite Orbit Satellites in the Fixed-Satellite Service in the Ka-band and V-band*, Order and Authorization, 24 FCC Rcd. 2330, 2347-48 ¶¶ 70-76 (IB Feb. 23, 2009).

[76] *Id.* ¶ 75.

[77] *See* Parts III.R, DD; Attachment 2.

C. Waiver of § 25.156(d)(4)

Karousel seeks a waiver of section 25.156(d)(4) of the Commission's rules. Section 25.156(d)(4) of the Commission's rules indicates that an application for feeder link authority will be treated by the Commission as a separate application from its associated service bands. The Karousel system will use the same spectrum for both service links and feeder links on a switchable basis; therefore, Karousel requests that the Commission grant a waiver of section 25.156(d)(4) of the rules.

In the Karousel system, the 14.0-14.5 GHz uplink and 19.7-20.2 GHz downlink bands will have the capability to switch from gateway to service links based on the needs of the system. The return link will be lightly utilized relative to the forward link, and the amount of data flowing over these links during times of normal operation is expected to be small. Therefore, when return link support is needed, all or part of the 14.0-14.5 GHz and 19.7-20.2 GHz bands will switch from the forward direction (gateway to satellite to user) to the return direction (user to satellite to gateway). This design promotes efficiency because the return link will have light use the majority of the time, handling just short user messages. On occasion, however, the return link traffic volume may be high, and the system is designed to maintain a sufficient level of capacity to accommodate these bursts in activity. Given the innovative design of the Karousel service, if these spectrum blocks were dedicated to the return link, these blocks would be underutilized most of the time. Allowing sharing with the forward link will ensure the spectrum is put to full use and will be available for high volume return link traffic, when needed.

Karousel's proposed approach maximizes the efficiency of the spectrum; therefore, good cause exists for the Commission to waive the requirements of section 25.156(d)(4).

D. Waiver of § 25.156(d)(5)

Out of an abundance of caution, Karousel seeks a waiver of section 25.156(d)(5) of the Commission's rules. The rule states that:

> In cases where the Commission has not adopted frequency-band specific service rules, the Commission will not consider NGSO-like applications after it has granted a GSO-like application, and it will not consider GSO-like applications after it has granted an NGSO-like application, unless and until the Commission establishes NGSO/GSO sharing criteria for that frequency band.

The Commission has not adopted frequency-band specific service rules for the bands that are the subject of this processing round, and certain of the bands that are the subject of this application have been assigned to GSO operations. To the extent section 25.156(d)(5) applies in this context, waiving the provision will ensure processing of the NGSO applications of Karousel and other similarly situated applicants.

V. SPECTRUM-SHARING CAPABILITIES

A. Space-to-Earth Communications

1. 10.7-12.7 GHz

a) 10.7-12.2 GHz

The 10.7-12.7 GHz band includes a primary non-federal allocation to the FSS in the space-to-earth direction and a primary non-federal allocation to fixed services in the 10.7-11.7 GHz segment. Karousel will use this band for space-to-earth links to users.

Karousel is completing the EPFD analysis described in section 25.208(g) as required by section 25.146(a) and the initial results confirm that Karousel's system will comply with the required $EPFD_{down}$ limits in all cases.[78] Also, consistent with section 25.146(b), Karousel will submit a technical showing demonstrating compliance with the operational EPFDdown limits in

[78] As described in Part IV of this Application, Karousel has sought a temporary waiver to allow sufficient time to model the showing using the software identified in section 25.146(a).

sections 25.208(i) and (j) ninety days prior to operation and will also comply with the aggregate limits of in section 25.208(h). In addition, Karousel will comply with note US131 which requires NGSO licensees operating in the 10.7-11.7 GHz band to coordinate with radio astronomy facilities operating in the 10.6-10.7 GHz band prior to commencing operations. This coordination will also ensure compliance with the requirements of notes US211 and US74. Further, Karousel will comply with the requirement to coordinate its operations in the 10.7-10.95 GHz band (as well as the 11.2-11.45 GHz band) and with other NGSO licensees as described in note 5.441 and ITU RR No. 9.12.

As described in Part IV.A., Karousel is seeking a waiver of footnote NG52 in the 10.7-11.7 GHz non-federal allocation in of sections 25.202 of the Commission's rules to permit the use of the 10.7-11.7 GHz band for downlink satellite transmissions other than transmissions to or from gateway earth stations. Karousel shall not claim protection from other geostationary satellite networks and shall rapidly eliminate any unacceptable interference that may occur as a result of its operations. Karousel will also coordinate its operations with GSO FSS earth stations as required by section 25.146(f) when the threshold conditions described in that section are met.

b) 12.2-12.7 GHz

The 12.2-12.7 GHz band includes a primary non-federal allocation to the Broadcasting Satellite Service ("BSS"), a primary non-federal allocation to fixed MVDDS services, and an additional primary allocation in note 5.487A for NGSO FSS operations. Karousel will use this band for space-to-earth links to users. Pursuant to the provisions of note 5.487A, Karousel will coordinate its operations in the 12.2-12.7 GHz bands with other NGSO licensees as described in ITU RR No. 9.12.

Karousel is completing the EPFD analysis described in section 25.208(l) as required by section 25.146(a) and the initial results confirm that Karousel's system will comply with the

required $EPFD_{up}$ limits in all cases. In addition, although Karousel has already confirmed that its system will comply with the PFD requirements of section 25.208(o), Karousel will submit a technical showing as required by section 25.146(g) ninety days prior to commencing operations demonstrating that compliance. Karousel will also submit a technical showing demonstrating compliance with notes 2 and 3 to Table 1L in section 25.208(l) as required by section 25.146(b). In addition, Karousel will comply with the aggregate EPFDdown limits in section 25.208(m). Karousel will also coordinate its operations with GSO FSS earth stations as required by section 25.146(f) when the threshold conditions described in that section are met.

2. 17.8-19.3 GHz

This band includes a primary Federal allocation to the FSS in the space-to-Earth direction. In the non-Federal table, the 17.8-18.3 GHz band includes a primary allocation to Fixed Services, and the 18.3-19.3 GHz segment includes a primary allocation to the FSS in the space-to-Earth direction. There is also a Federal and non-Federal primary allocation to passive Space Research and Earth Exploration Satellite services in the 18.6-18.8 GHz segment of the band. Karousel will use this band for space-to-Earth links from Karousel satellites to users. Section 25.208(c) includes PFD limits for 18.3-18.8 GHz and 25.208(e) includes PFD limits for 18.8-19.3 GHz. Karousel has completed calculations that demonstrate compliance with these requirements. In addition, note US255 includes a PFD limit specific to the 18.6-18.8 GHz segment of the band, and Karousel's calculations also demonstrate compliance with this requirement. Karousel also has completed calculations that demonstrate compliance with the PFD limits described in ITU RR Article 21, Table 21-4 for the 17.7-19.3 GHz band and is completing calculations to demonstrate compliance with the EPFD limits defined in ITU RR Article 22, Table 22-1B for the 17.8-18.6 GHz band. Finally, Karousel will comply with the requirement in US334(a) to coordinate operations with Federal FSS systems.

B. Earth-to-Space Communications

1. 14.0-14.5 GHz

The 14.0-14.5 GHz band includes a primary non-federal allocation to FSS in the Earth-to-space direction, as well as a secondary non-federal allocation to the Mobile Satellite Service, a secondary federal and non-federal allocation to Space Research in 14.0-14.2 GHz, and a secondary federal allocation to fixed and mobile services in 14.4-14.5 GHz. Karousel will use this band for earth-to-space links from both gateways and users to Karousel satellites on a switchable, as needed basis.

Karousel is completing the EPFD analysis described in 25.208(k) as required by 25.146(a). The initial results confirm that Karousel's system will comply with the required $EPFD_{up}$ limits in all cases. In addition, to protect the Space Research service, note US133 and section 25.227(c) impose restrictions on Earth Stations Aboard Aircraft ("ESAA") operating in the band. Karousel will be compliant with this requirement because ESAA operations will not be supported in the Karousel system. Further, notes US113 and US342 require that every practicable effort shall be made to avoid assignment of 14.47-14.5 GHz to protect radio astronomy observations of critical formaldehyde line frequencies. Karousel will comply with these requirements for both gateway and user uplinks. First, although gateway locations have not yet been determined, every effort will be made to locate Karousel earth stations as far from the radio astronomy locations listed in US113. Second, the occupied bandwidth of Karousel's transmissions does not include the band 14.47-14.5 GHz. Third, the system will be designed such that user return links will not be assigned frequencies in the 14.47-14.5 GHz band.

2. 27.5-30.0 GHz

The 27.5-29.5 GHz segment of this band includes a primary non-Federal allocation to the Fixed Satellite Service in the Earth-to-space direction, a primary non-Federal allocation to Fixed

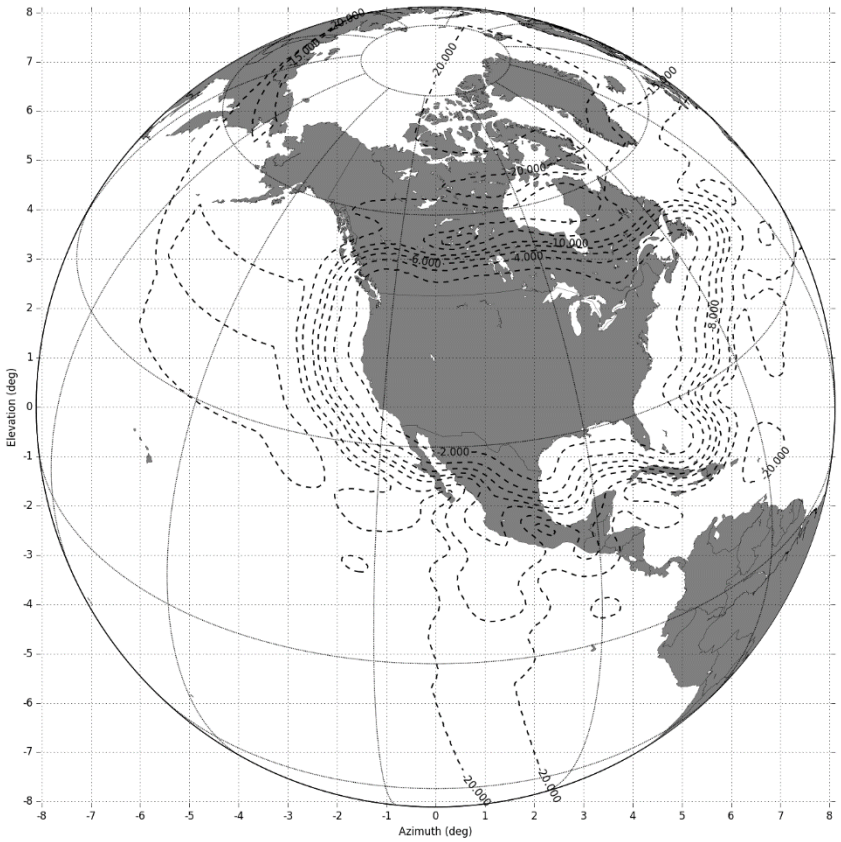
Services, and a primary non-Federal allocation to Mobile Services. The 29.5-30.0 GHz segment includes a primary non-Federal allocation to the FSS and a primary non-Federal allocation to the Mobile-Satellite Service, both in the Earth-to-space direction. Consistent with note 5.529, the MSS allocation in Region 2 in most of the band is limited to satellite networks that are in both the Fixed Satellite Service and the Mobile Satellite Service.

Karousel intends use this band for Earth-to-space links from gateways to Karousel satellites. Section 25.202 of the Commission's rules designates NGSO operations as secondary in all segments of this band except 28.6-29.1 GHz. As a secondary service, section 2.105(c)(2)(i) requires that Karousel "[s]hall not cause harmful interference to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date." Karousel acknowledges that it must not cause harmful interference to existing or future primary users assigned to the band.

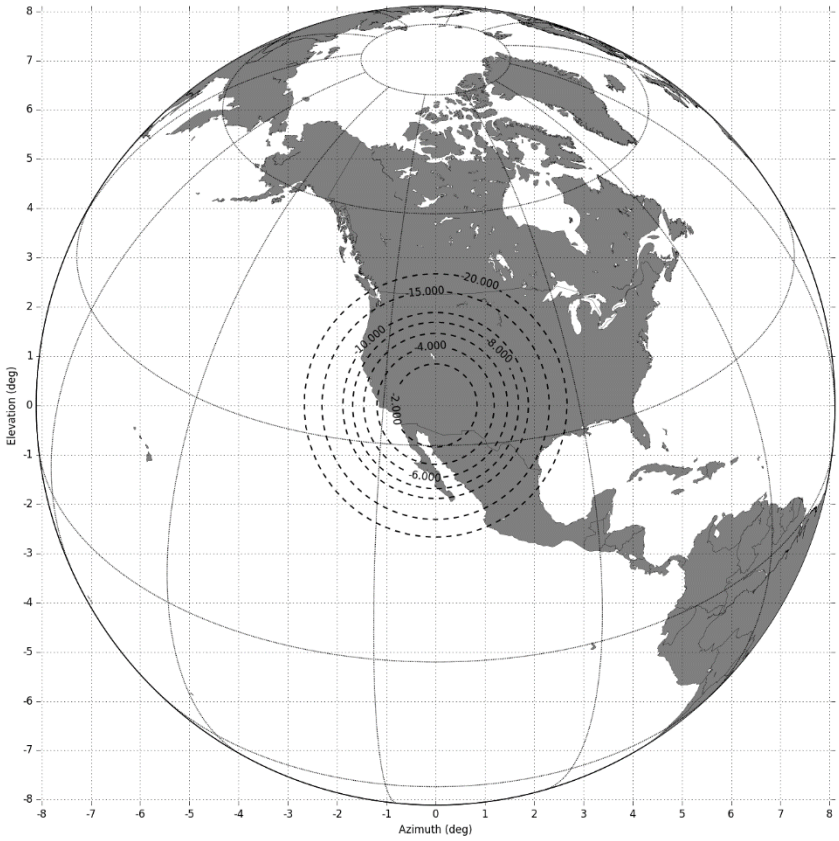
The Commission also recently adopted new rules for the 27.5-28.35 GHz band. Formerly, this band was used for the Local Multipoint Distribution Service ("LMDS") service, and it now supports the Upper Microwave Flexible Use Service ("UMFUS"). Pursuant to the most recent rule revisions, Karousel is required to protect both current and future licensees in this segment; however, interference to UMFUS licensees will be easily managed. First, Karousel will use this band for uplink operations from gateway locations. Second, elevation angles to Karousel satellites will be high relative to other systems. And third, gateway locations are likely to be in less populated areas where terrestrial system deployments are less prevalent. Furthermore, Karousel will comply with the requirement in section 25.203(j) that requires coordination with licensees of FSS and terrestrial systems sharing the band. Karousel's service is unlikely to cause harmful interference in the band and, in any case, Karousel acknowledges that it must not create harmful interference to existing or future primary users assigned to the band.

ATTACHMENT 1

Antenna Gain Contours for Beams UU1A, UU1B, UD1A, UD1B, UD1C, UD1D, UD1E, UD1F
Contours are plotted on the surface of the Earth.
Contours are at -2 dB, -4 dB, -6 dB, -8 dB, -10 dB, -15 dB and -20 dB relative to beam peak.



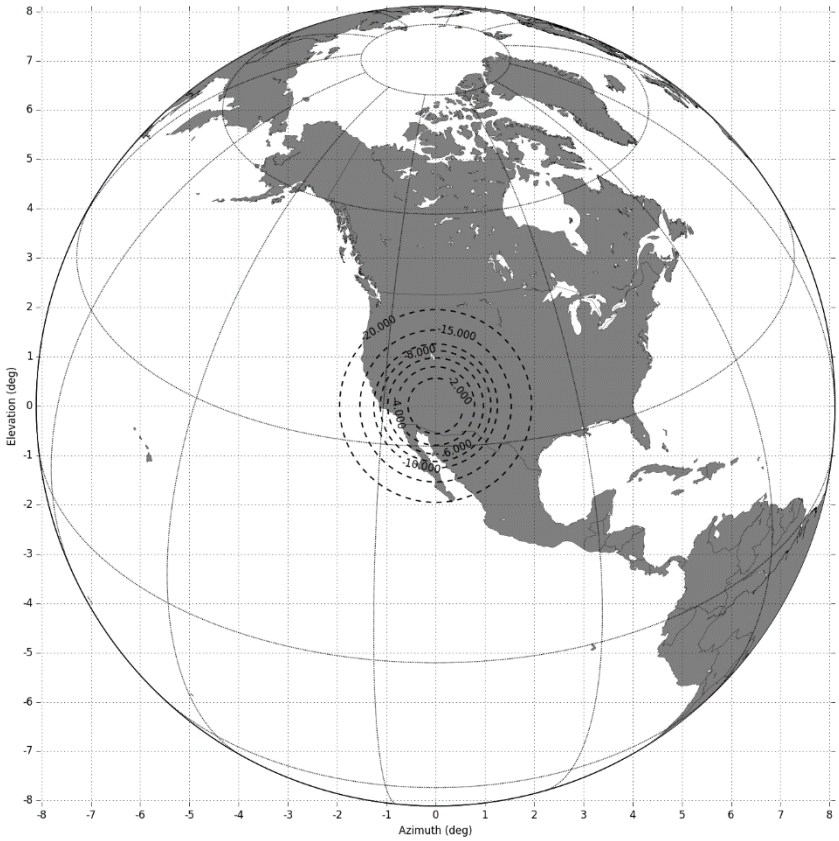
Antenna Gain Contours for Beams GU5A, GU5B, GU6A, GU6B, GD5E, GD5F, GD6E, GD6F
Contours are plotted on the surface of the Earth with the space station peak antenna gain pointed at nadir to a latitude and longitude within the proposed service area.
Contours are at -2 dB, -4 dB, -6 dB, -8 dB, -10 dB, -15 dB and -20 dB relative to beam peak.



Antenna Gain Contours for Beams GU5C, GU5D, GU6C, GU6D

Contours are plotted on the surface of the Earth with the space station peak antenna gain pointed at nadir to a latitude and longitude within the proposed service area.

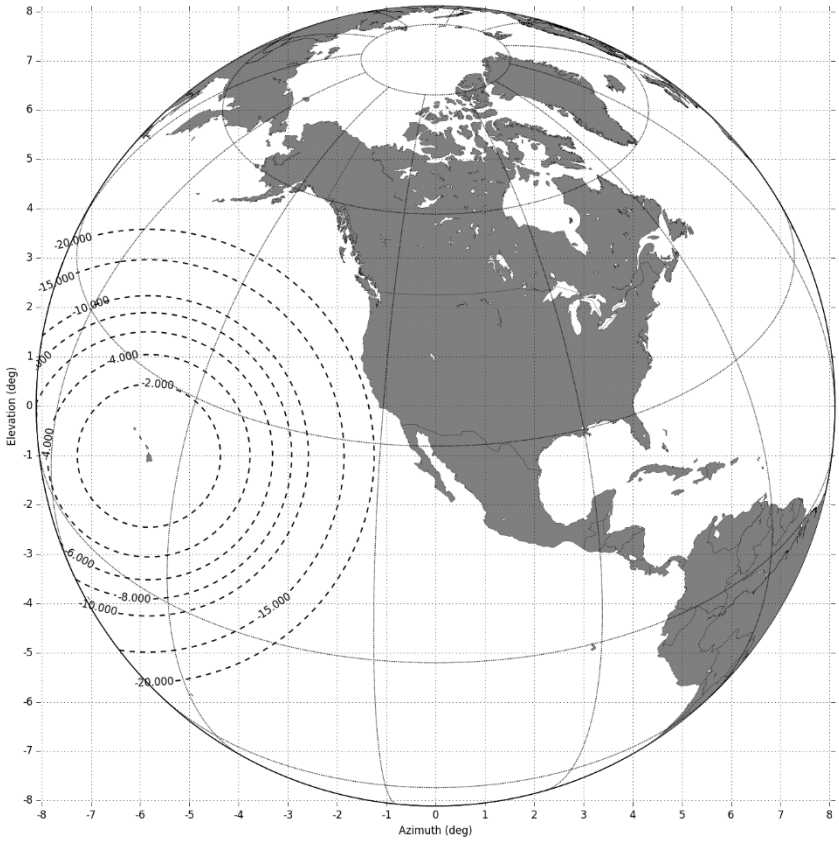
Contours are at -2 dB, -4 dB, -6 dB, -8 dB, -10 dB, -15 dB and -20 dB relative to beam peak.



Antenna Gain Contours for Beams UD3A, UD3B

Contours are plotted on the surface of the Earth with the space station peak antenna gain pointed at nadir to a latitude and longitude within the proposed service area.

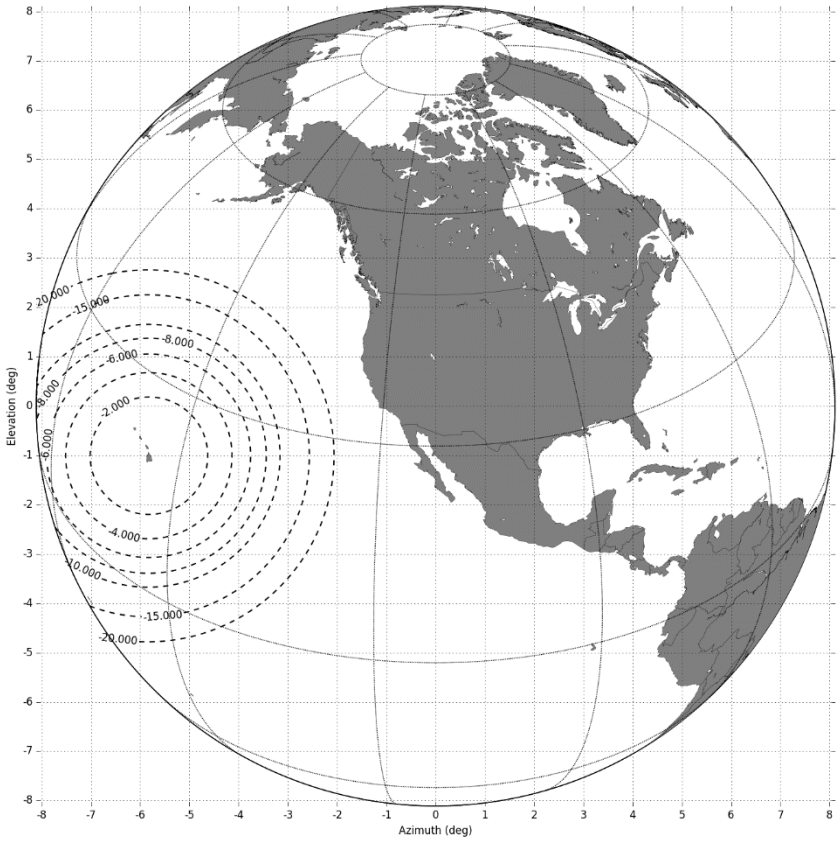
Contours are at -2 dB, -4 dB, -6 dB, -8 dB, -10 dB, -15 dB and -20 dB relative to beam peak.



Antenna Gain Contours for Beams UU3A, UU3B

Contours are plotted on the surface of the Earth with the space station peak antenna gain pointed at nadir to a latitude and longitude within the proposed service area.

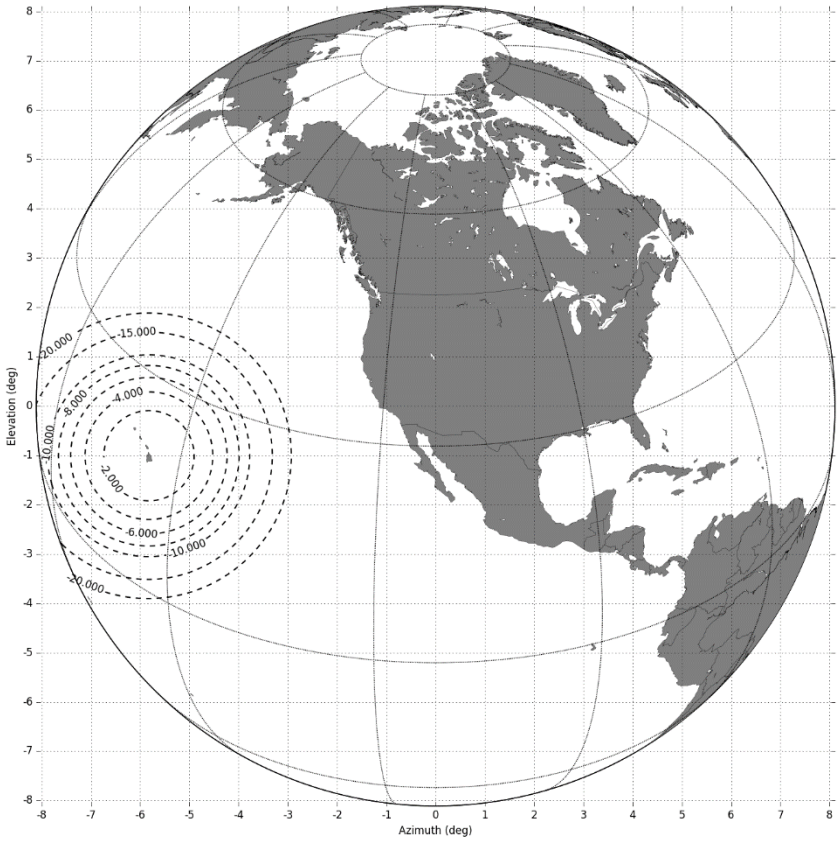
Contours are at -2 dB, -4 dB, -6 dB, -8 dB, -10 dB, -15 dB and -20 dB relative to beam peak.



Antenna Gain Contours for Beams UD3C, UD3D

Contours are plotted on the surface of the Earth with the space station peak antenna gain pointed at nadir to a latitude and longitude within the proposed service area.

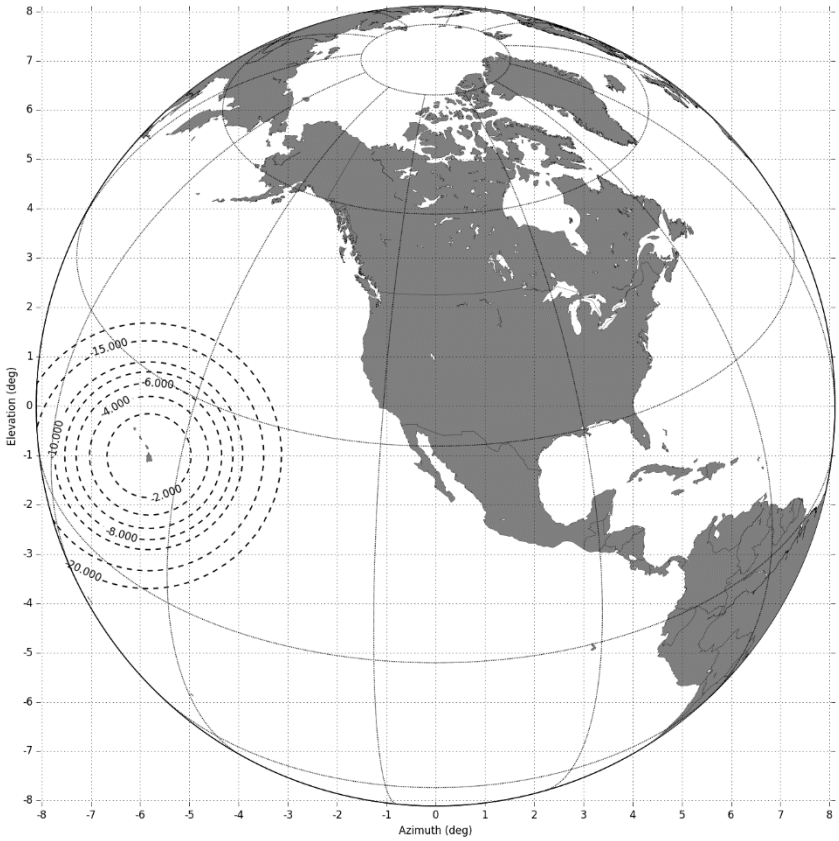
Contours are at -2 dB, -4 dB, -6 dB, -8 dB, -10 dB, -15 dB and -20 dB relative to beam peak.



Antenna Gain Contours for Beams UD3E, UD3F

Contours are plotted on the surface of the Earth with the space station peak antenna gain pointed at nadir to a latitude and longitude within the proposed service area.

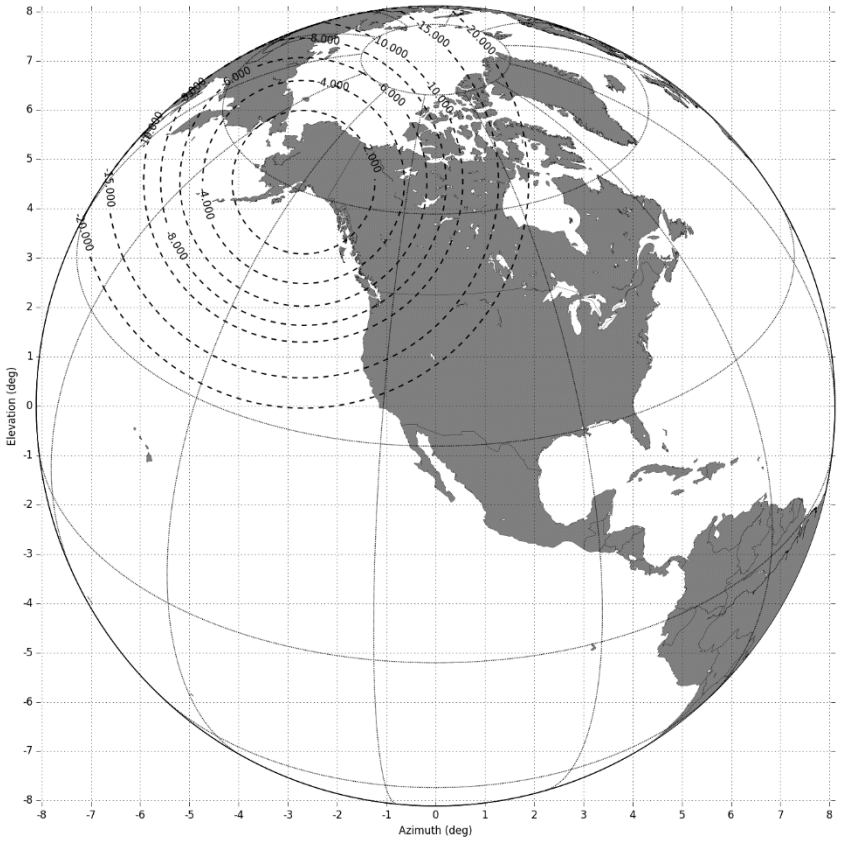
Contours are at -2 dB, -4 dB, -6 dB, -8 dB, -10 dB, -15 dB and -20 dB relative to beam peak.



Antenna Gain Contours for Beams UD2A, UD2B

Contours are plotted on the surface of the Earth with the space station peak antenna gain pointed at nadir to a latitude and longitude within the proposed service area.

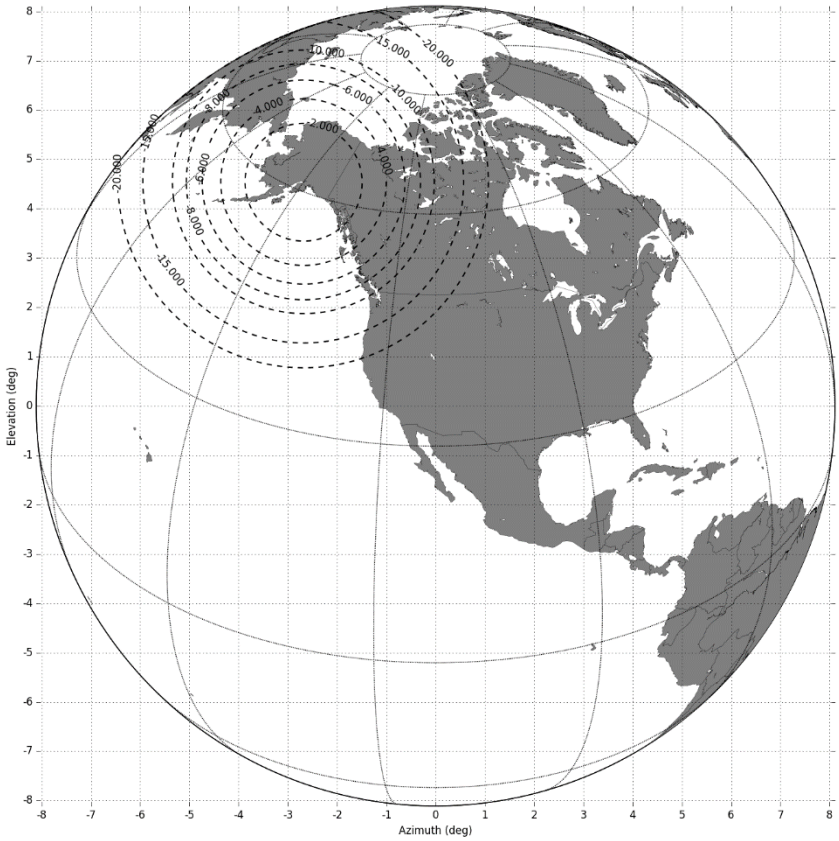
Contours are at -2 dB, -4 dB, -6 dB, -8 dB, -10 dB, -15 dB and -20 dB relative to beam peak.



Antenna Gain Contours for Beams UU2A, UU2B

Contours are plotted on the surface of the Earth with the space station peak antenna gain pointed at nadir to a latitude and longitude within the proposed service area.

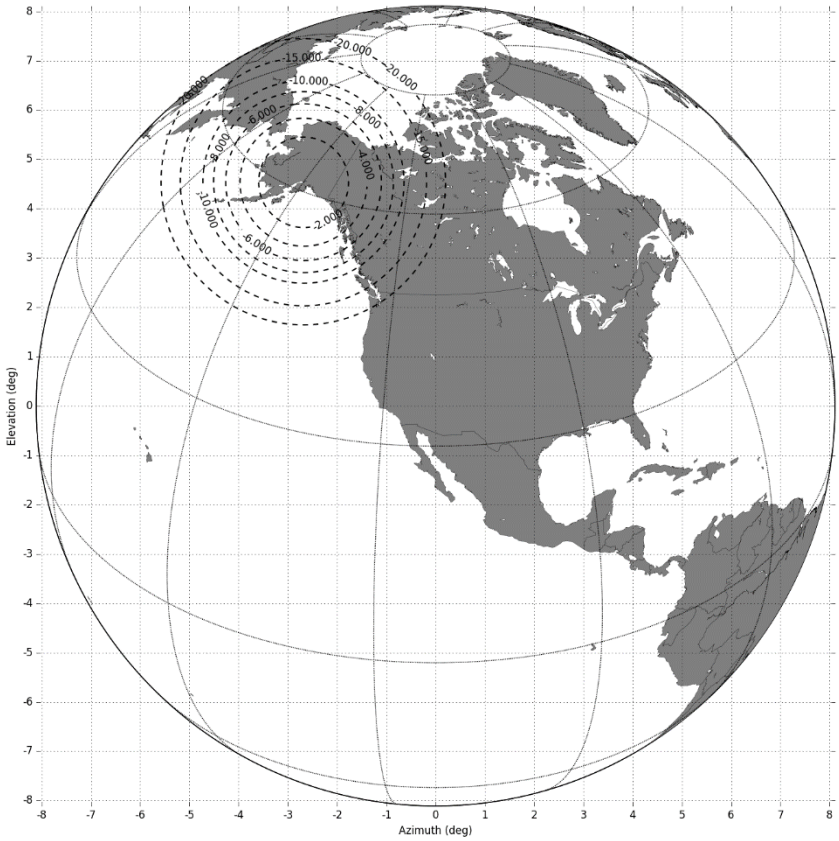
Contours are at -2 dB, -4 dB, -6 dB, -8 dB, -10 dB, -15 dB and -20 dB relative to beam peak.



Antenna Gain Contours for Beams UD2C, UD2D

Contours are plotted on the surface of the Earth with the space station peak antenna gain pointed at nadir to a latitude and longitude within the proposed service area.

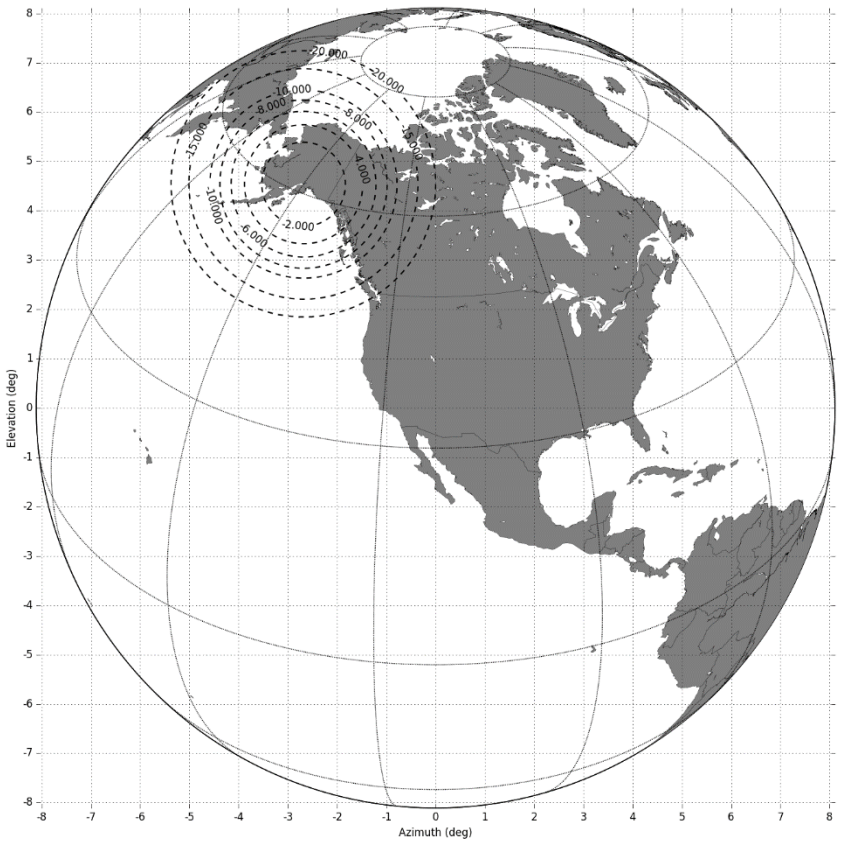
Contours are at -2 dB, -4 dB, -6 dB, -8 dB, -10 dB, -15 dB and -20 dB relative to beam peak.



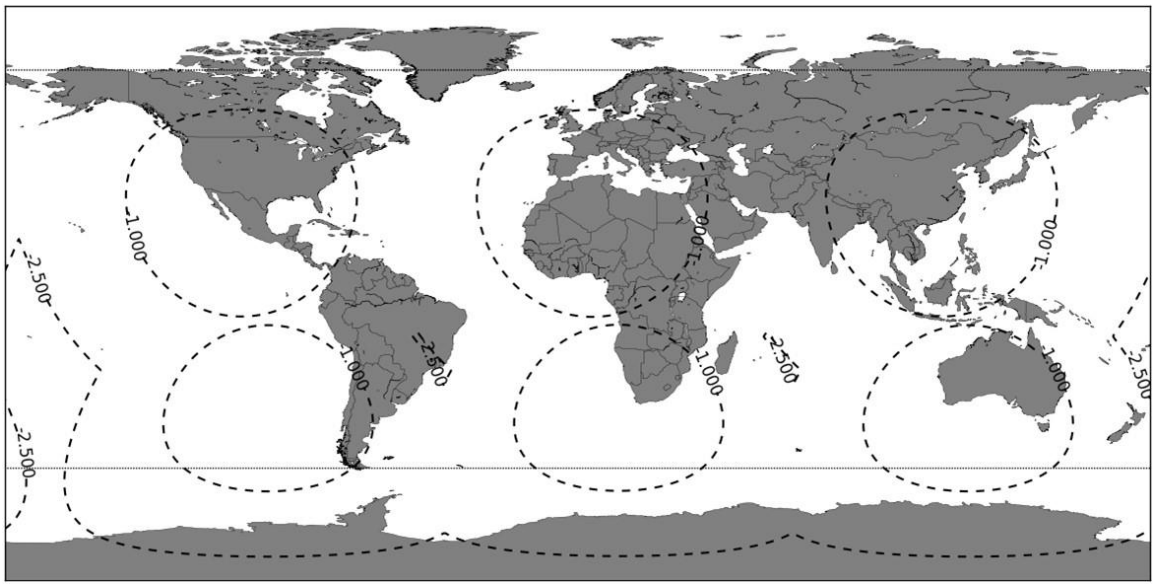
Antenna Gain Contours for Beams UD2E, UD2F

Contours are plotted on the surface of the Earth with the space station peak antenna gain pointed at nadir to a latitude and longitude within the proposed service area.

Contours are at -2 dB, -4 dB, -6 dB, -8 dB, -10 dB, -15 dB and -20 dB relative to beam peak.

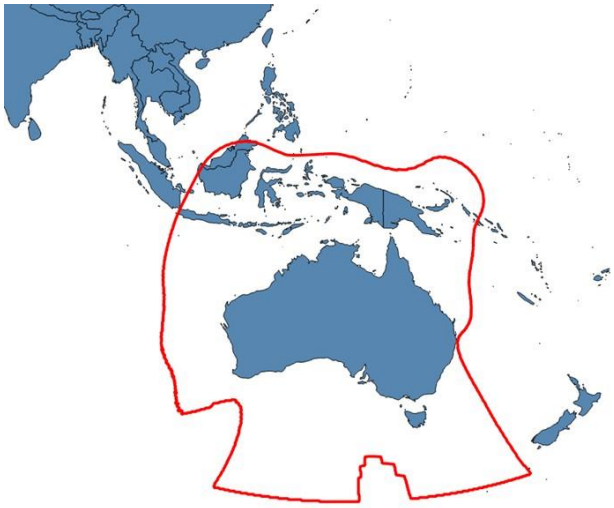


Antenna Gain Contours for Beams UU4A, UU4B, UD4A, UD4B, UD4C, UD4D, UD4E, UD4F
Combined contours from 3 equally spaced satellites are plotted on the surface of the Earth. Contours are at -1 dB and -2.5 dB relative to peak gain; -2.7 dB covers the entire Earth.

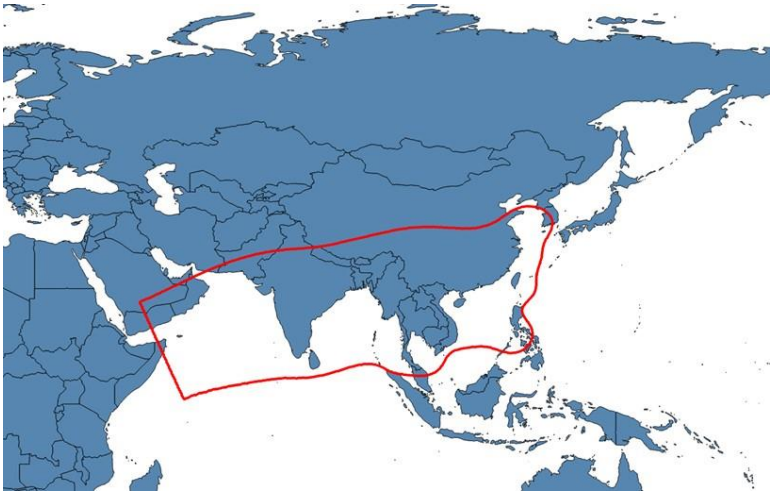


Example coverage of South America from satellite located at 85° West Longitude

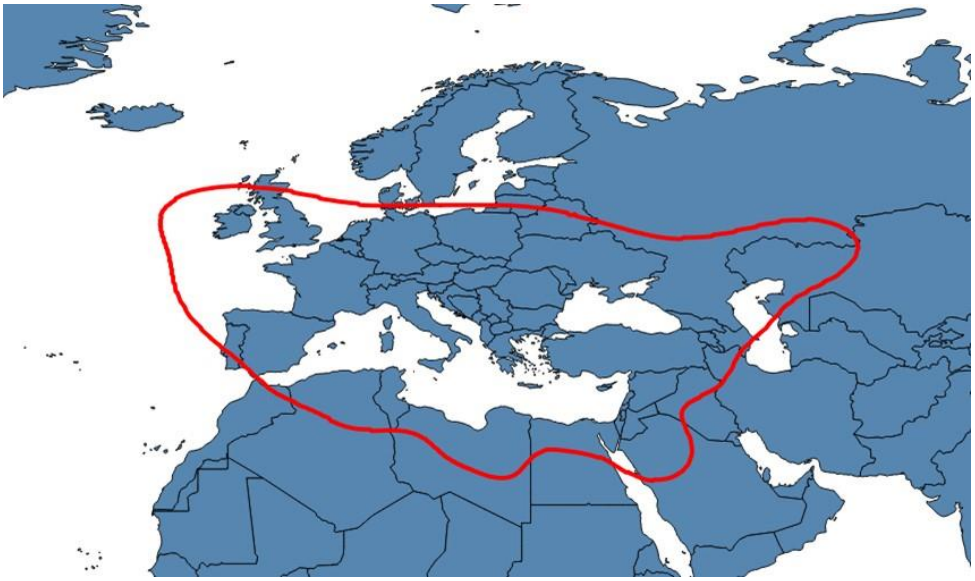
Example coverage of Australia from a satellite located at 135° East Longitude



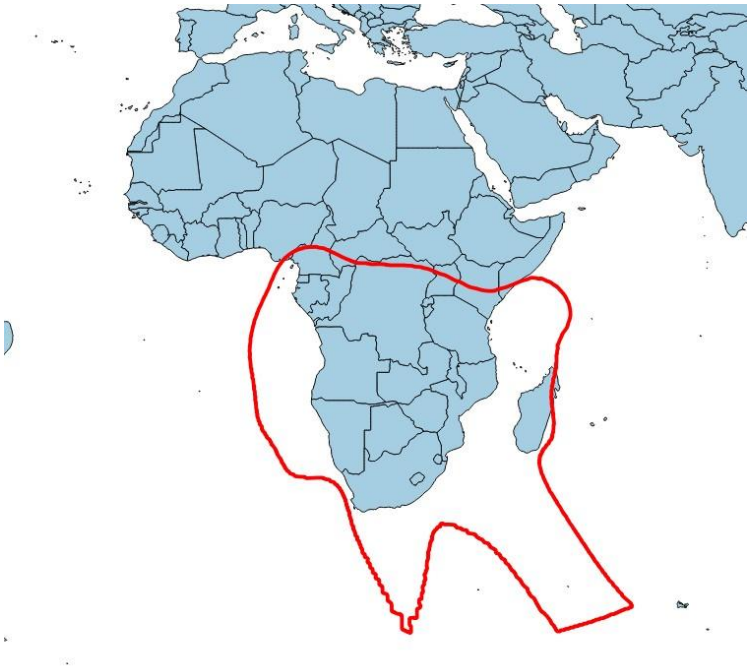
Example coverage of Asia from a satellite located at 135° East Longitude



Example coverage of Europe from a satellite located at 25° East Longitude



Example coverage of Africa from a satellite located at 25° East Longitude



ATTACHMENT 2

This attachment provides a detailed explanation of the worst-case EPFD levels produced by the Karousel system in Ku-band and how they comply with the single-entry EPFD validation limits in section 25.146(a)(1) and (2).

Ku-band $EPFD_{down}$

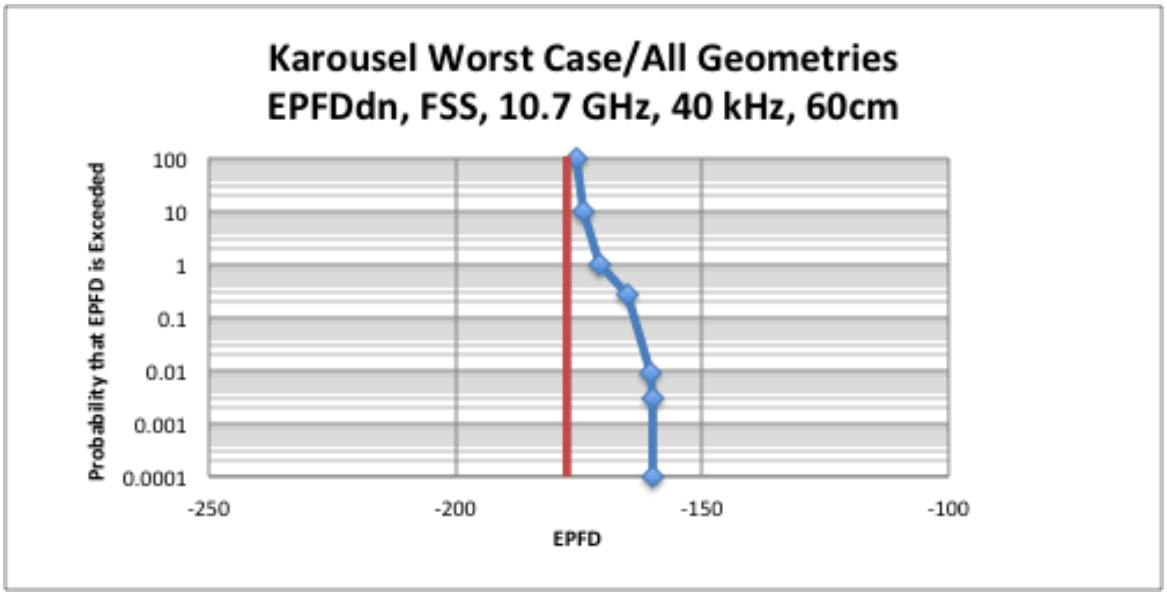
For this analysis with respect to sections 25.208(g) and 25.208(l), Karousel uses a worst-case uniform PFD mask on the surface of the Earth of -139.6 $dBW/m^2/40$ kHz for all Ku-band downlink beams and channels. Only a single transponder channel is active at a time for any given satellite. As a worst-case assumption, these PFD levels are assumed constant given the nature of the Karousel system.

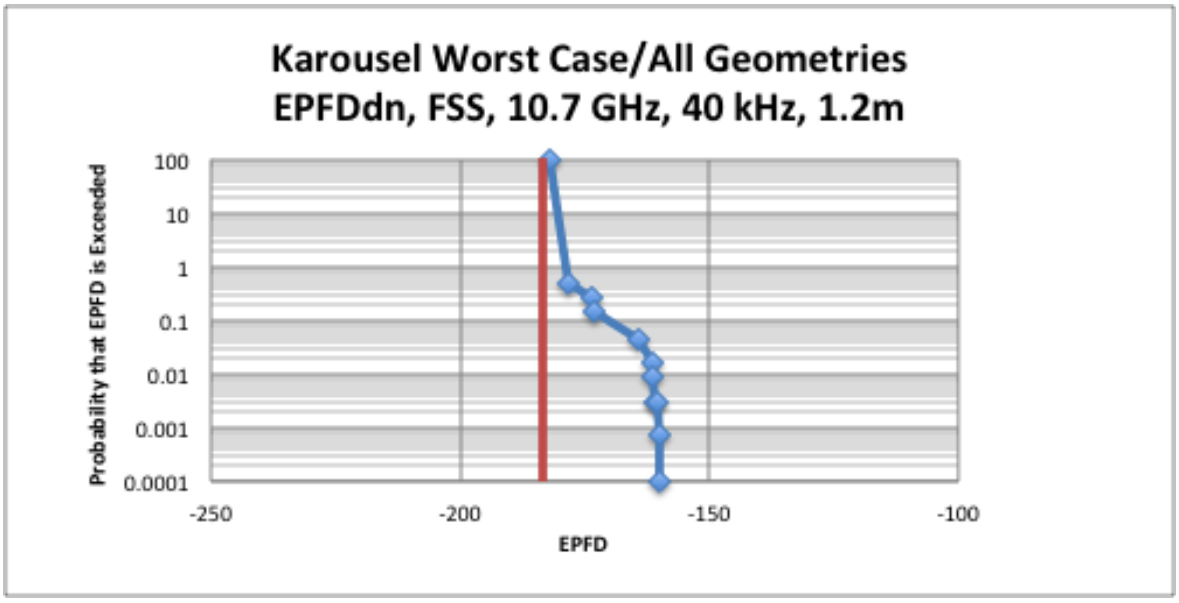
When available, Karousel will provide less conservative (more realistic) results from an approved Recommendation ITU-R S.1503 software program. In the interim, Karousel is providing the Commission with sets of Ku-band power flux-density (PFD) calculations as well as the resulting EPFD and antenna discrimination calculations.

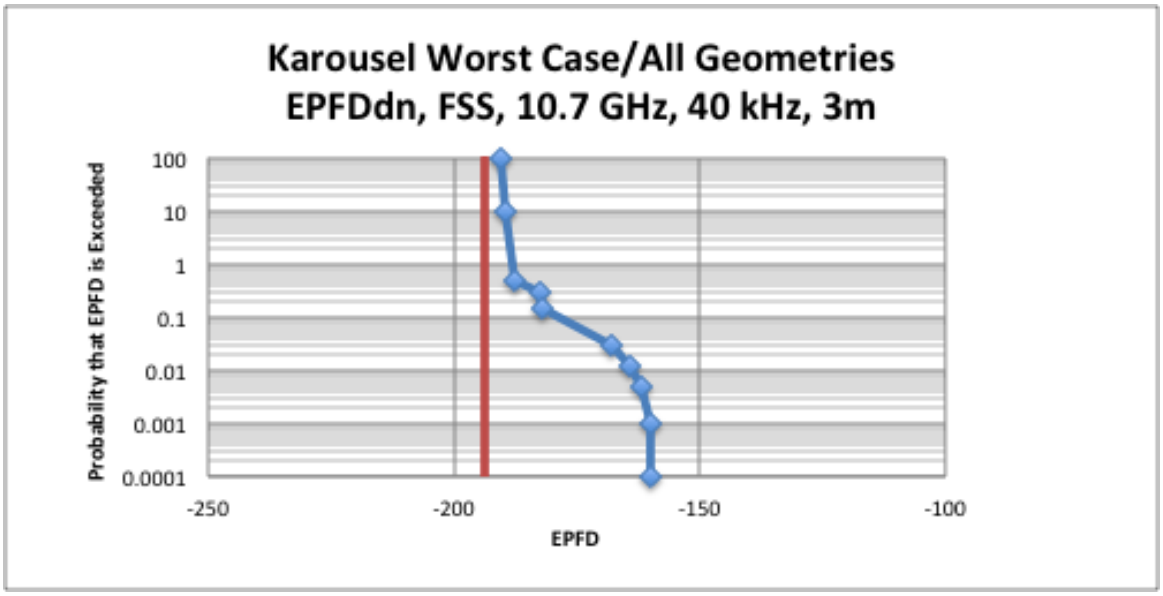
The Ku-band $EPFD_{down}$ results from the EPFD validation Excel spreadsheet using the input data explained above are shown below. Each plot corresponds to one of the GSO reference earth station antenna sizes from the EPFD limits. The labeling of each diagram indicates the frequency, the reference bandwidth (40 kHz), the size of the GSO reference earth station antenna, and whether this is a BSS or FSS EPFD limit. Given the worst-case methodology, the analysis is valid for all geometries of operation.

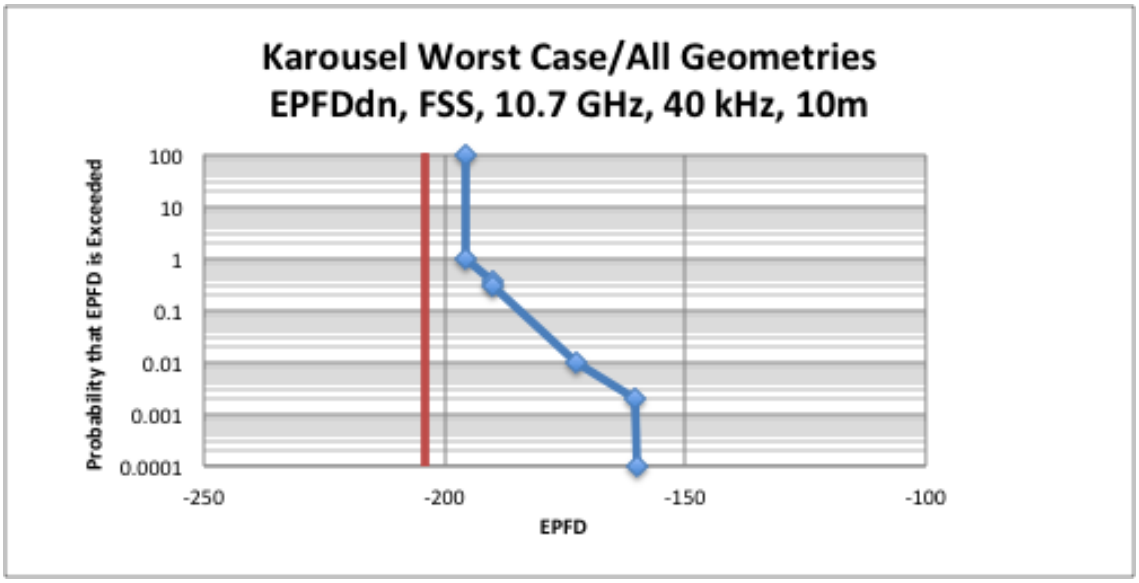
On each diagram the resulting EPFD level is shown by the red curve and the EPFD mask that applies is shown by the blue curve. From these results, it can be seen that this analysis also

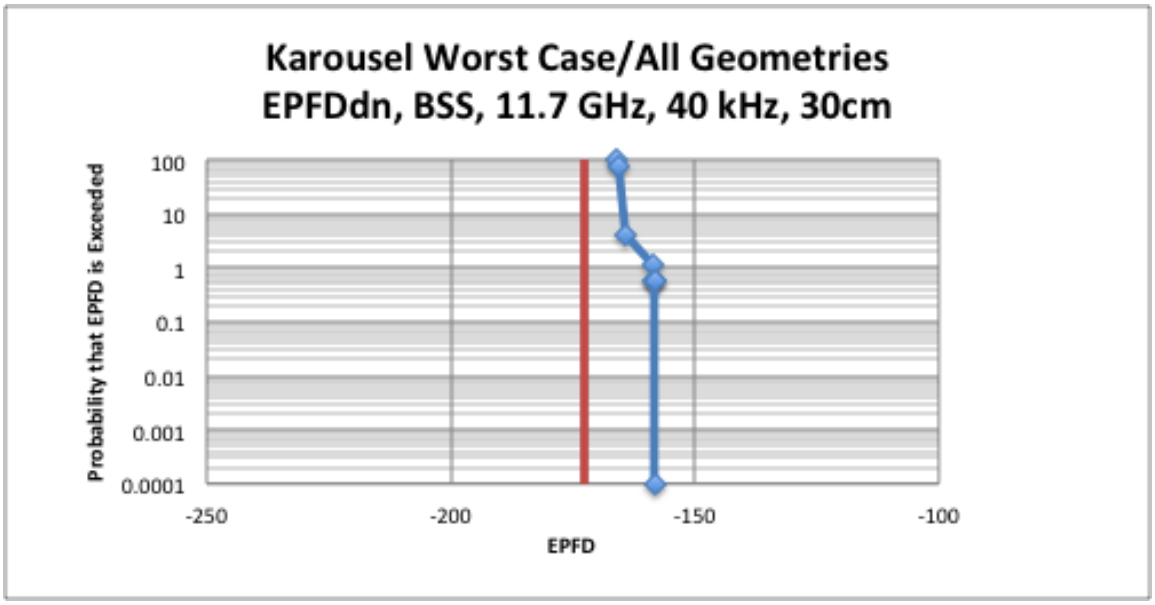
takes into account the high latitude EPFD limits given in Table 2G of 25.208(g) for the GSO FSS and Table 2L of 25.208(l) for the GSO BSS, with these limits also being met.

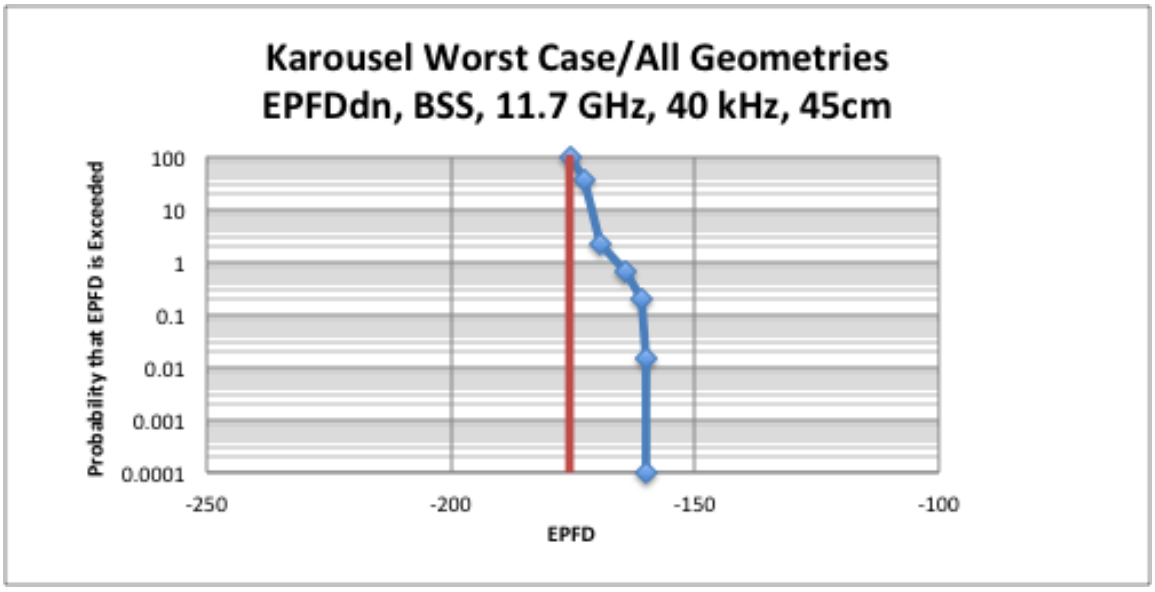


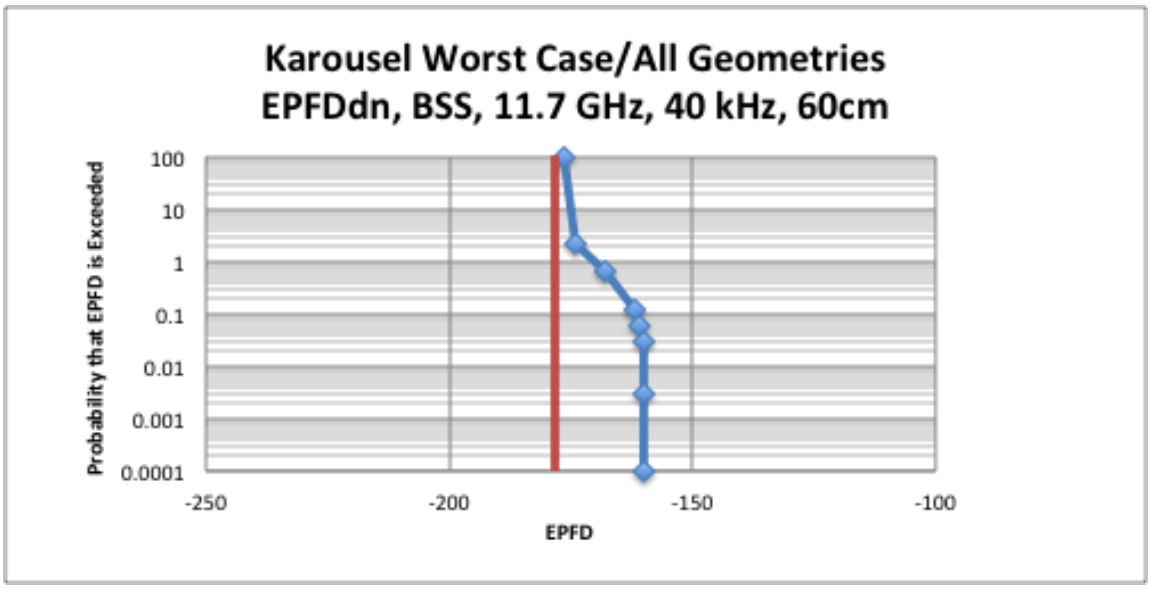


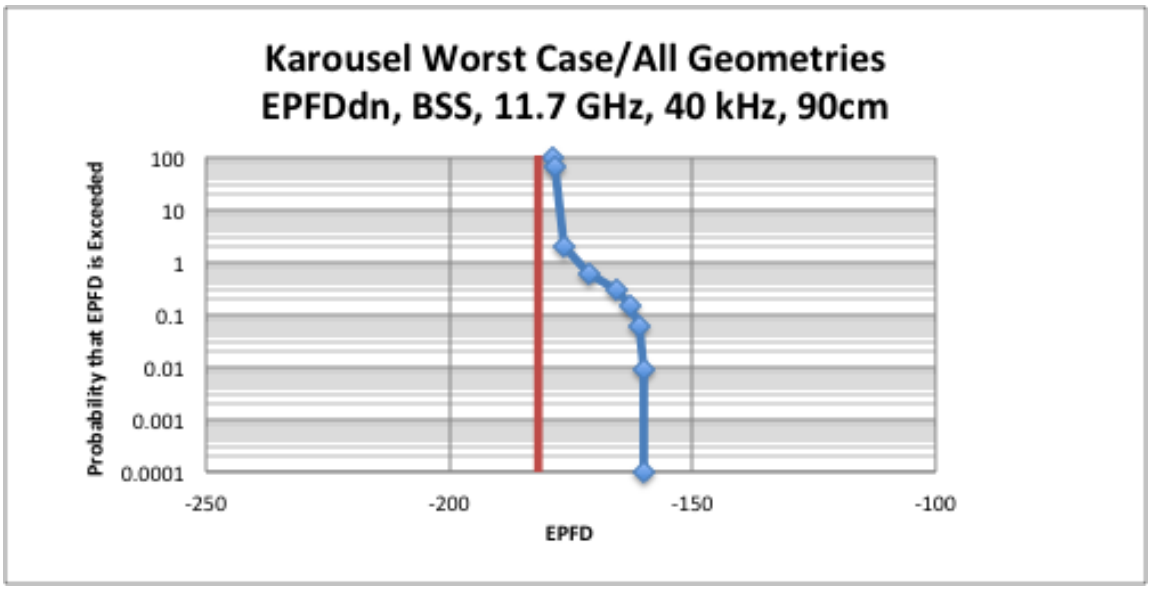

Karousel Worst Case/All Geometries
EPFDdn, FSS, 10.7 GHz, 40 kHz, 3m
Probability that EPFD is Exceeded
100
10
1
0.1
0.01
0.001
0.0001
-250
-200
-150
-100
EPFD

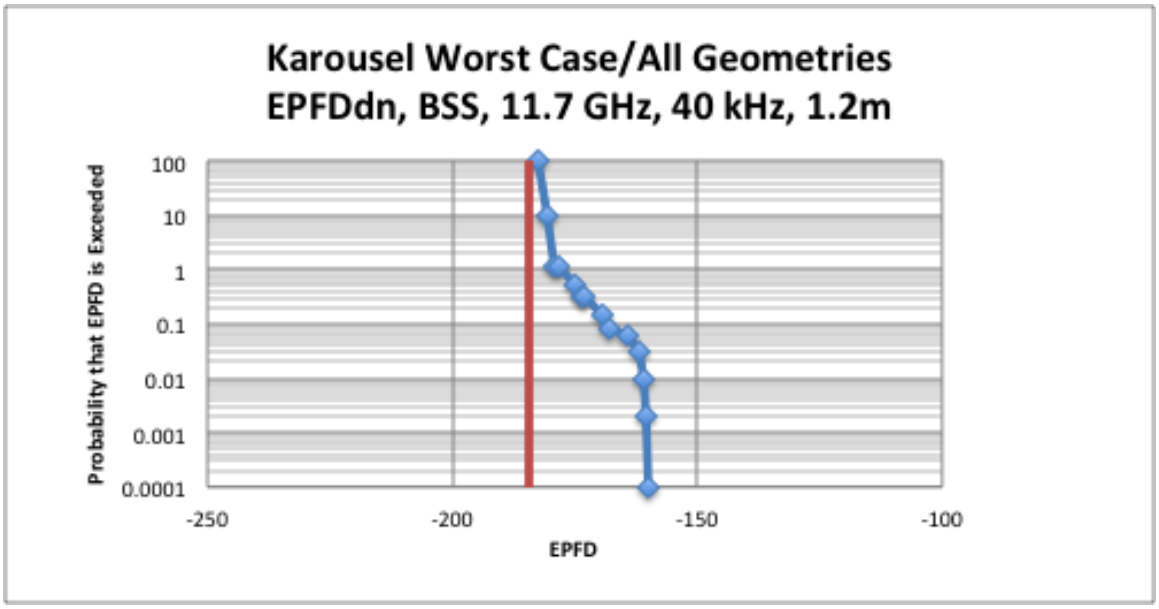

Karousel Worst Case/All Geometries
EPFDdn, FSS, 10.7 GHz, 40 kHz, 10m
Probability that EPFD is Exceeded
100
10
1
0.1
0.01
0.001
0.0001
-250
-200
-150
-100
EPFD

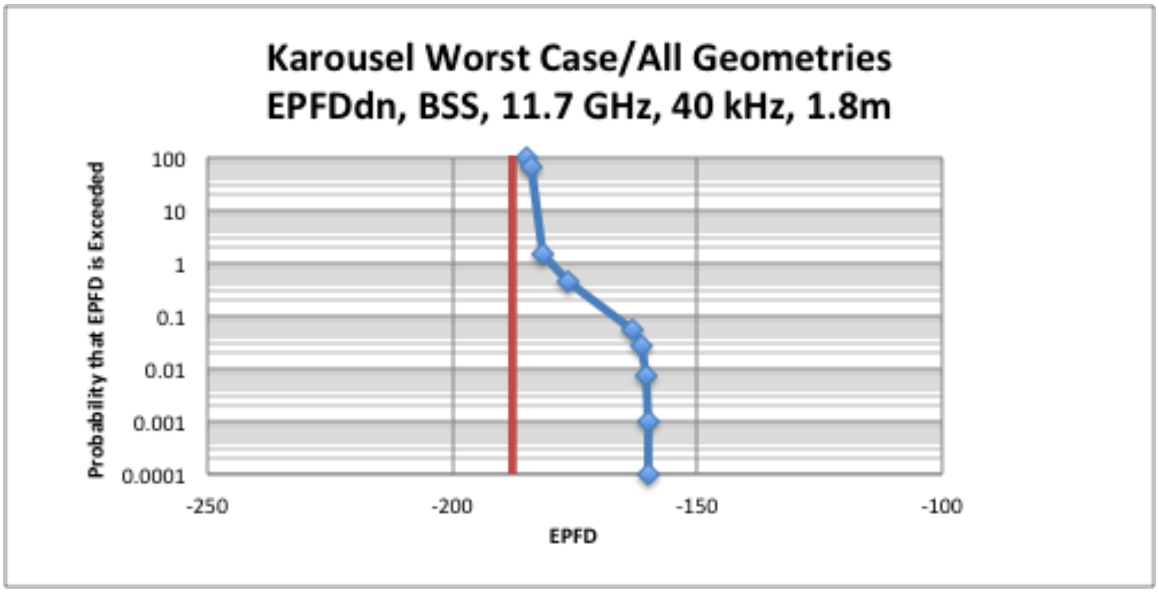

Karousel Worst Case/All Geometries
EPFDdn, BSS, 11.7 GHz, 40 kHz, 30cm
Probability that EPFD is Exceeded
100
10
1
0.1
0.01
0.001
0.0001
-250
-200
-150
-100
EPFD

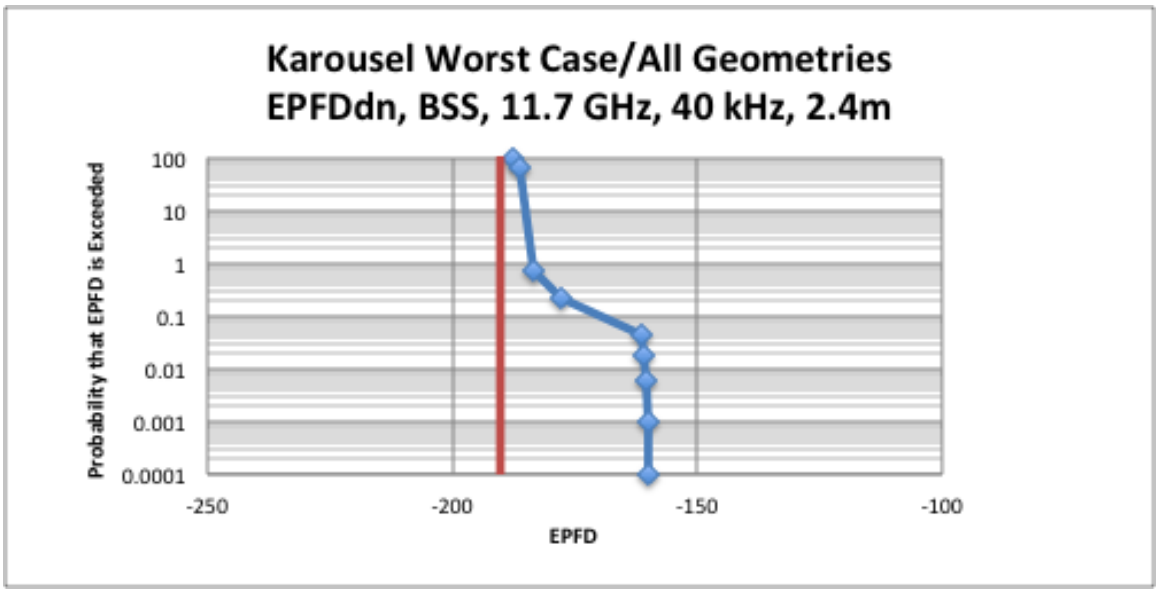

Karousel Worst Case/All Geometries
EPFDdn, BSS, 11.7 GHz, 40 kHz, 45cm
Probability that EPFD is Exceeded
100
10
1
0.1
0.01
0.001
0.0001
-250
-200
-150
-100
EPFD

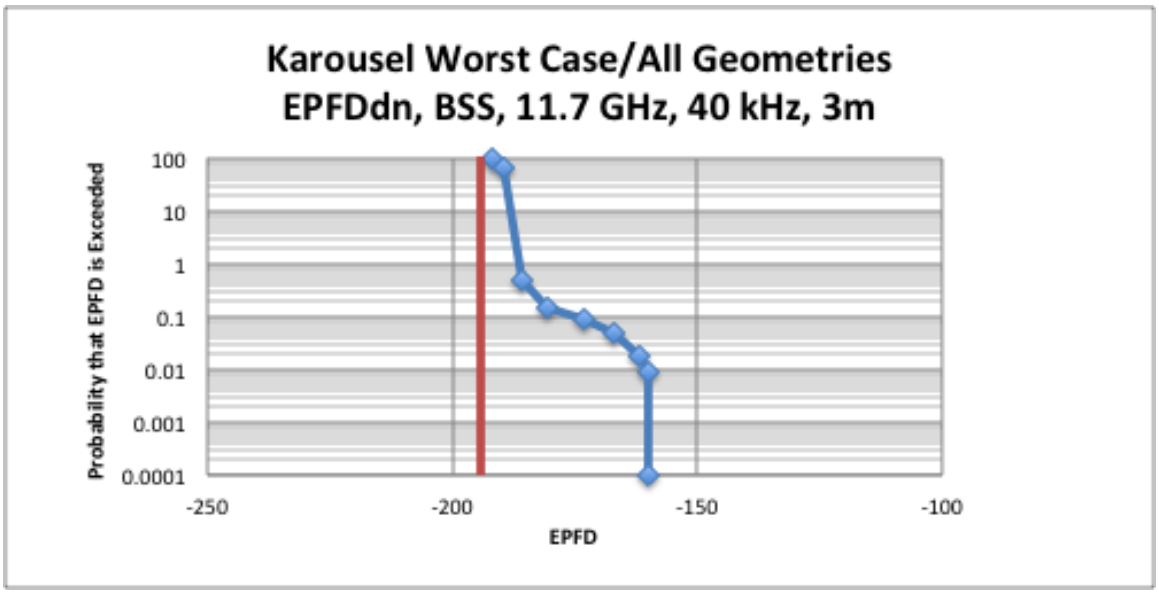

Karousel Worst Case/All Geometries
EPFDdn, BSS, 11.7 GHz, 40 kHz, 60cm
Probability that EPFD is Exceeded
100
10
1
0.1
0.01
0.001
0.0001
-250
-200
-150
-100
EPFD


Karousel Worst Case/All Geometries
EPFDdn, BSS, 11.7 GHz, 40 kHz, 90cm
Probability that EPFD is Exceeded
100
10
1
0.1
0.01
0.001
0.0001
-250
-200
-150
-100
EPFD


Karousel Worst Case/All Geometries
EPFDdn, BSS, 11.7 GHz, 40 kHz, 1.2m
Probability that EPFD is Exceeded
100
10
1
0.1
0.01
0.001
0.0001
-250
-200
-150
-100
EPFD


Karousel Worst Case/All Geometries
EPFDdn, BSS, 11.7 GHz, 40 kHz, 1.8m
Probability that EPFD is Exceeded
100
10
1
0.1
0.01
0.001
0.0001
-250
-200
-150
-100
EPFD





Ku-band $EPFD_{up}$

For this analysis with respect to section 25.208(k), Karousel evaluates various worst-case Ku-band gateway and terminal conditions for the 14.0-14.5 GHz band to determine how many gateways or terminals can be supported at the peak of the GSO reference uplink beam. No GSO satellite antenna discrimination is assumed in this analysis. The worst-case geometry of GSO

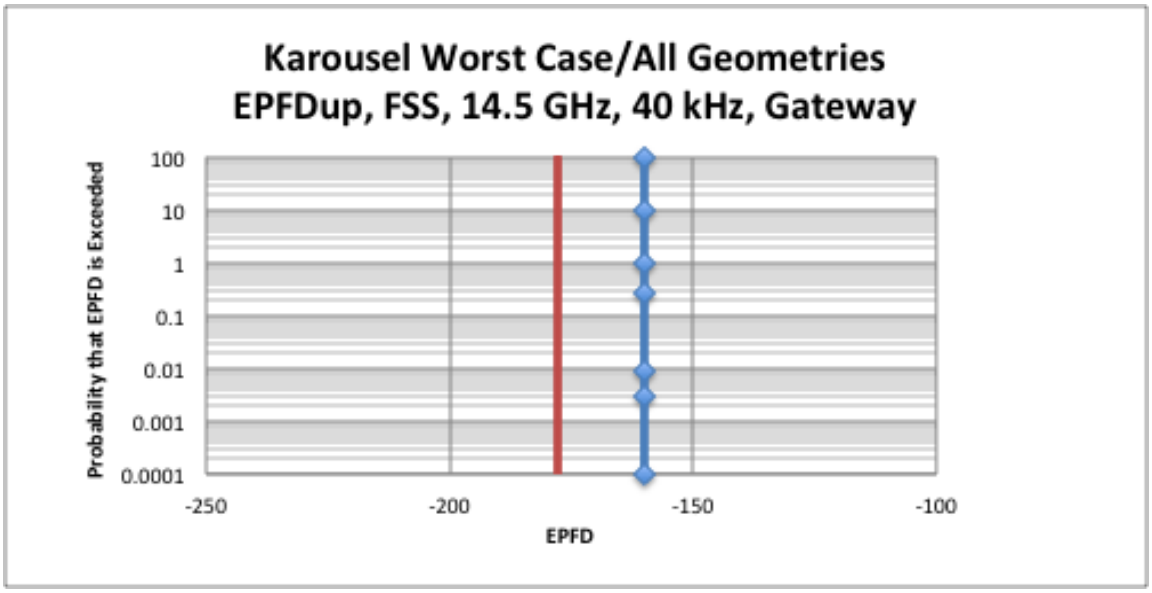
sub-satellite on the equator is used to compute the spreading loss to the GSO, which results in a value of -162.1 dB/m^2.

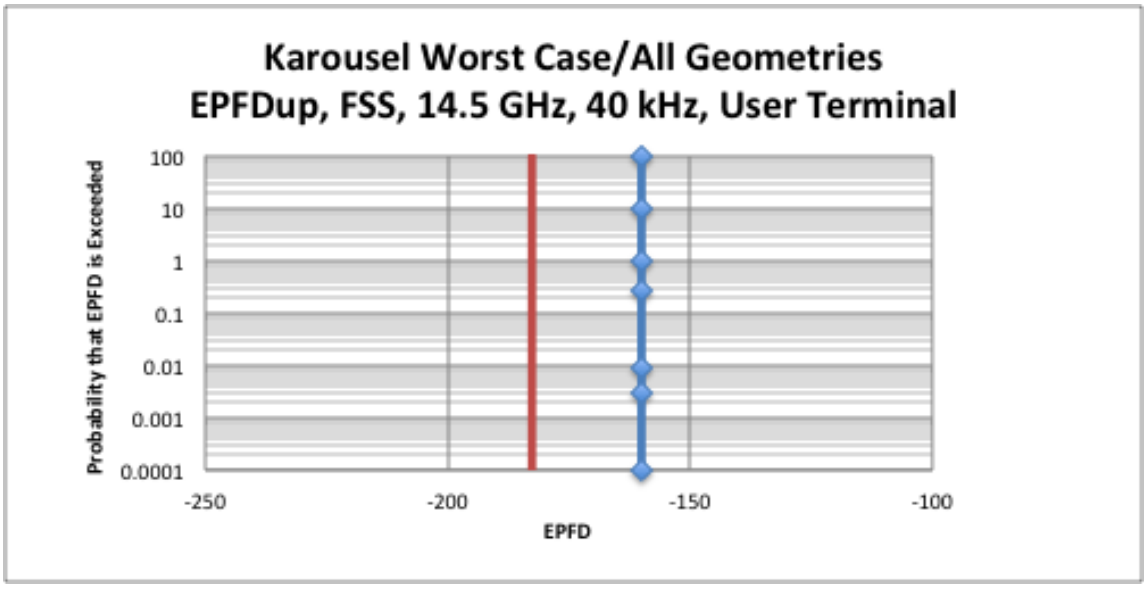
When available, Karousel will provide less conservative (more realistic) results from an approved Recommendation ITU-R S.1503 software program. In the interim, Karousel is providing the Commission with sets of Ku-band power flux-density (PFD) calculations as well as the resulting EPFD and Karousel uplink antenna discrimination calculations, which conform to ITU-R S.1428-1, with a 1-degree pointing error included which reduces the resulting antenna discrimination towards the GSO satellite arc.

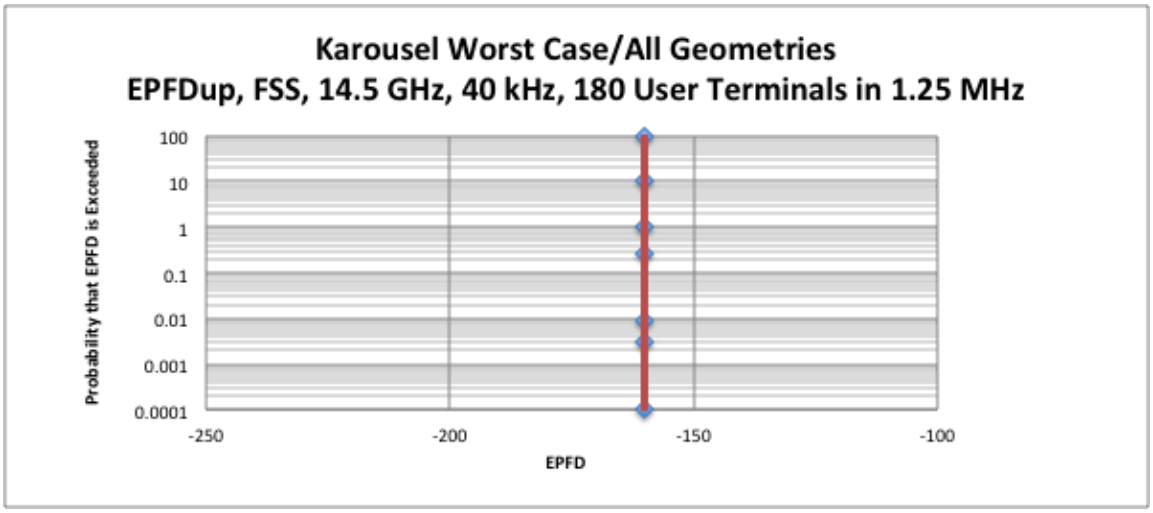
The Ku-band $EPFD_{up}$ results from the EPFD validation Excel spreadsheet using the input data explained above are shown below. Each curve on the plot corresponds to one of the Karousel NGSO reference earth station antenna configurations from the spreadsheet analysis. The labeling of each diagram indicates the frequency, the reference bandwidth (40 kHz), the size of the GSO reference earth station antenna, and whether this is a BSS or FSS EPFD limit. Given the worst-case methodology, the analysis is valid for all geometries of operation.

On the following diagrams the resulting EPFD levels are shown by the red curve and the EPFD mask that applies is shown by the blue curve. Gateway and user cases are shown for single instances. Only a single gateway transmission per frequency is planned, although several simultaneous uplinks to different Karousel NGSO satellites can be supported while meeting the requirements of section 25.208(k). Multiple user terminals may be accessing the Karousel satellite at the same time in the same portion of the channel. A limiting case is also shown which supports the equivalent of 180 user terminal uplinks in 1.25 MHz, all from the peak of the GSO reference beam. This case translates into more than 29,000 simultaneous user capacity in the 200-megahertz channel passband, and more than 2.9 million terminals at a conservative duty

cycle of 1 percent. The Karousel system does not expect to approach this level of return-channel traffic and will have substantial margin to the requirements of section 25.208(k) when active.






Karousel Worst Case/All Geometries
EPFDup, FSS, 14.5 GHz, 40 kHz, 180 User Terminals in 1.25 MHz
Probability that EPFD is Exceeded
100
10
1
0.1
0.01
0.001
0.0001
-250
-200
-150
-100
EPFD

ATTACHMENT 3

Acknowledgement of Commencement of Space Station Construction at Applicant's Own Risk

Karousel LLC ("Karousel"), pursuant to Section 25.113(f) of the Commission's rules, hereby acknowledges that any construction commenced prior grant of an authorization of the authority sought through this application will be at Karousel's own risk.

/s/ *Monish Kundra*

Monish Kundra
Vice President
Karousel LLC

Dated: November 15, 2016

ATTACHMENT 4

Technical Certification

I, John L. Norin, hereby certify that I am the technically qualified person responsible for the preparation of the engineering information contained in the technical portions of the foregoing application and the related attachments, that I am familiar with Part 25 of the Commission's rules, and that the technical information is complete and accurate to the best of my knowledge and belief.

/s/ *John L. Norin*

John L. Norin
Principal, Strategic Advisor
BRPG, LLC
Weston, FL
john@br-pg.com

Dated: November 15, 2016