

**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, DC 20554**

In the Matter of

Expanding Access to Broadband and Encouraging  
Innovation through Establishment of an Air-  
Ground Mobile Broadband Secondary Service for  
Passengers Aboard Aircraft in the 14.0-14.5 GHz  
Band

GN Docket No. 13-114  
RM-11640

**COMMENTS OF QUALCOMM INCORPORATED**

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## SUMMARY

Qualcomm strongly supports the FCC's Notice of Proposed Rulemaking proposing to establish an Air-Ground Mobile Broadband Service in the 14.0-14.5 GHz band, on a secondary basis, to enable airplane passengers to enjoy high-speed, high-capacity Internet connectivity while flying above the continental United States. Millions of U.S. air travelers are carrying smartphones, tablets, e-readers, and laptops on board aircraft and they fully expect to use those devices in the air with the same level of broadband connectivity that they have on the ground. The FCC will bring tremendous benefits to consumers by authorizing this new service, which will be offered at a very reasonable cost using innovative terrestrial-based technology.

As the Commission itself explains in the NPRM, "broadband aboard aircraft will lead to improved connectivity for business and leisure travelers alike. Business travelers will have a greater ability to message, research and download information, and send finished products. Leisure travelers will have greater options to use broadband to communicate with friends and family members, use social media, play games, and research their destinations or other areas of interest." Moreover, the new service will allow air travelers to stream videos, movies, television programming, radio stations, and any other content of their choice.

Qualcomm is pleased the FCC recognizes that the 14 GHz band can support a multi-gigabit-per-second air-ground communications system that will not interfere with incumbent operations and will not itself suffer any harmful interference, as Qualcomm's earlier detailed technical filings demonstrated. Qualcomm supports the Commission's proposed regulatory framework and technical operating rules, which are based upon the proposals in Qualcomm's Petition for Rulemaking. We encourage the FCC to issue a Report and Order establishing the new service and conduct an auction as soon as possible thereafter, so the traveling public can experience the high-quality, high-capacity in-flight broadband experience they demand.

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RM-11640

**COMMENTS OF QUALCOMM INCORPORATED**

QUALCOMM Incorporated (“Qualcomm”) is pleased to offer these comments in response to the Commission’s Notice of Proposed Rulemaking in the above-captioned proceeding.<sup>1</sup> As the NPRM explains, the proposed service will extend to the aircraft cabin the same level of broadband access that users currently enjoy on the ground wherever they happen to be — in their homes, workplaces, public parks, on sidewalks, and in moving vehicles.<sup>2</sup> Qualcomm is particularly pleased that the NPRM recognizes that the proposed Air-Ground Mobile Broadband Service can operate on a secondary licensed basis in the 14.0 - 14.5 GHz band without causing interference to primary satellite operations and other incumbent users of this band and without suffering any interference. As explained in these Comments, Qualcomm strongly encourages the Commission to promptly establish the proposed innovative service in

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<sup>1</sup> See *Expanding Access to Broadband and Encouraging Innovation through Establishment of an Air-Ground Mobile Broadband Secondary Service for Passengers Aboard Aircraft in the 14.0-14.5 GHz Band*, Notice of Proposed Rulemaking, GN Docket No. 13-114, RM-11640, FCC 13-66, 28 FCC Rcd 6765 (2013) (“NPRM”).

<sup>2</sup> See *id.* at ¶¶ 1, 18 and Statement of Chairman Julius Genachowski.

accordance with the NPRM so that U.S. air travelers can have high-speed, high-capacity broadband access while in-flight.

## **DISCUSSION**

### **I. The Proposed Air-Ground Mobile Broadband Service Is Needed Now Because U.S. Travelers Are Rapidly Adopting A Connected Lifestyle That Requires Ubiquitous Broadband Connectivity While In-Flight**

There is no question that smartphones, tablets, e-readers, and other mobile devices are becoming “increasingly interwoven into our daily lives.”<sup>3</sup> They “empower people to stay informed and connected with friends and family and enable both large and small businesses to be more productive and efficient, helping to drive economic growth and boost U.S. competitiveness.”<sup>4</sup> Consequently, the need to enable anywhere/anytime broadband connectivity — including while flying in an airplane above the continental United States (“CONUS”) — is critically important for a rapidly increasing number of American travelers.

#### **A. The Growth Of Mobile Broadband-Enabled Devices Continues Unabated**

Recent statistics, when compared to those that were included in Qualcomm’s Petition for Rulemaking (“Petition”) filed two years ago, underscore today’s increasingly connected lifestyle

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<sup>3</sup> Letter from FCC Chairman Julius Genachowski to the Honorable Michael P. Huerta, Acting Administrator, Federal Aviation Administration (Dec. 6, 2012) (encouraging the FAA to enable greater use of tablets, e-readers and other portable electronic devices during flight). The FAA also reportedly recognizes that “consumers are intensely interested in the use of personal electronics aboard aircraft...” Nick Bilton, “F.A.A. to Consider Relaxed Rules for Devices on Planes,” NYTimes.com (June 21, 2013) available at [http://bits.blogs.nytimes.com/2013/06/21/f-a-a-set-to-relax-rules-for-devices-on-planes/?\\_r=0](http://bits.blogs.nytimes.com/2013/06/21/f-a-a-set-to-relax-rules-for-devices-on-planes/?_r=0).

<sup>4</sup> *Id.* “[B]roadband is no longer a luxury, it is a necessity.” Prepared Remarks of FCC Acting Chairwoman Mignon L. Clyburn, M-Enabling Summit, Arlington, VA (June 6, 2013) available at [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2013/db0607/DOC-321475A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2013/db0607/DOC-321475A1.pdf).

where mobile broadband-enabled devices are integrated into the personal and business lives of millions of American workers and consumers who demand full-time broadband access.<sup>5</sup>

For example, earlier this year, the Commission reported that U.S. mobile Internet subscriptions had grown to 142 million, reflecting an increase of 46% from 2010 to 2011.<sup>6</sup> CTIA – The Wireless Association recently announced that at the end of 2012 there were 152.1 million smartphones and wireless-enabled PDAs in service, an increase of 36.4% over the end of 2011.<sup>7</sup>

Prognostications of future trends show the continued growing use of mobile broadband-enabled devices. The Consumer Electronics Association (“CEA”) recently reported that 40% of online U.S. consumers already own a tablet computer, that 41% of these consumers plan to purchase a tablet computer in the next 24 months, and that nearly 75% of these consumers expect to purchase a tablet at some point in the future.<sup>8</sup> Not surprisingly, global tablet shipments in 2013 are expected to top 170 to 180 million units.<sup>9</sup> CEA projected that 2013 sales of mobile

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<sup>5</sup> See Nate Flint, “E-Commerce Explodes on Mobile,” Flint Digital (Jan. 3, 2013) *available at* <http://www.flintdigital.com/mobile-e-commerce-explosion-fueled-by-mobile-use/> (mobile “devices are becoming an intrinsic part of our daily lives giving 24/7 access to social media, news, weather, entertainment, messaging, banking, GPS information and at the bottom of the list is using your phone to make calls”) (“Flint Digital”); *see also* Petition at 6-11.

<sup>6</sup> See FCC Report, “Internet Access Services: Status as of December 31, 2011,” Wireline Competition Bureau, Industry Analysis and Technology Division (rel. Feb. 2013).

<sup>7</sup> CTIA – The Wireless Association Press Release, CTIA Semi-Annual Survey (May 2, 2013) *available at* <http://www.ctia.org/media/press/body.cfm/prid/2261> (“CTIA Survey”). Indeed, more than 17.6 million mobile devices were activated on Christmas Day 2012 alone. *See* Flint Digital.

<sup>8</sup> CEA Press Release, CEA Quarterly Tablet Report (July 29, 2013), *available at* <http://www.ce.org/News/News-Releases/Press-Releases/2013-Press-Releases/Tablet-Adoption-Rates-Cool-in-Second-Quarter,-Acco.aspx> (“Sales of mobile connected devices, *i.e.*, smartphones and tablets, continue to drive growth for the entire CE industry. U.S. unit tablet shipments are estimated to reach 87.1 million by the end of 2013 (a 45% increase from 2012), while tablet revenues are estimated to reach \$27.3 billion in 2013 (a 9% increase from 2012).”).

<sup>9</sup> C114 “Global Tablet Shipments to top 170-180 million units in 2013,” (Jan. 16, 2013) *available at* <http://www.cn-c114.net/578/a741043.html>. In 2012, the CEA reported that “tablet computers are the fastest growing category in CE history.” CEA Press Release (Jan. 10, 2012).

connected devices would account for over 32% of the \$202+ billion U.S. consumer electronics industry.<sup>10</sup>

Thus, consumers are transitioning from traditional, fixed access broadband connections to anywhere/anytime Internet access enabled via mobile devices.<sup>11</sup> Cisco estimates that “[b]y the end of 2013, the number of mobile devices will exceed the number of people on earth, and by 2017, there will be nearly 1.4 mobile devices per person.”<sup>12</sup> The International Data Corporation has forecasted that by 2015, more U.S.-based users will access the Internet through mobile devices than through PCs and other wireline devices.<sup>13</sup>

### **B. The Mobile Application Economy Is Thriving And Driving Growth**

This shift from traditional wired to wireless Internet access is reflected in the exponential growth in consumer use of data-hungry applications, or “apps,” on smartphones and tablets. These apps provide quick access to social networking, photos, emails, documents, news, weather, literature, games, videos, TV shows, and movies via Facebook, Google+, Flickr,

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<sup>10</sup> CEA Press Release, “Mobile Connected Devices Drive CE Industry; Resurgence in Auto, Audio, TV Segments, Finds CEA Forecast” (July 24, 2013) available at <http://ce.org/News-Releases/Press-Releases/2013-Press-Releases/Mobile-Connected-Devices-Drive-CE-Industry;-Resurg.aspx>.

<sup>11</sup> See *Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993; Annual Report and Analysis of Competitive Market Conditions with Respect to Mobile Wireless, Including Commercial Mobile Services, Sixteenth Report*, 28 FCC Rcd 3700, 3712 (2013); see also “Mobile App Growth Exploding, and Shows No Signs of Letting Up,” Venture Beat (July 10, 2013) available at <http://venturebeat.com/2013/07/10/state-of-the-apposphere/> (“‘We’re seeing a tremendous disruption by mobile’ as huge numbers of people move from traditional web to mobile devices [,which is] being driven by the large number of mobile devices around the world – and there’s plenty of room for more growth.”) (“Venture Beat”).

<sup>12</sup> Cisco Visual Networking Index: Global Mobile Device Traffic Forecast Update, 2012-2017 at 3 (Feb. 6, 2013) available at [http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white\\_paper\\_c11-520862.pdf](http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.pdf) (“Cisco Report”).

<sup>13</sup> See International Data Corporation Worldwide New Media Market Model Forecast (September 12, 2011), available at <http://www.idc.com/getdoc.jsp?containerID=prUS23028711>.

dotPhoto, Shutterfly, Snapfish, Amazon, Blockbuster, Netflix, HBO GO, Hulu, CBS, NBC, ABC, CNN, YouTube, and the list goes on.<sup>14</sup> Users not only are using their devices more often, but the apps with which they regularly interact are becoming increasingly sophisticated with greater data needs.<sup>15</sup>

Popular social networking applications are routinely adding new features that take advantage of the increasing data capacity of today's 3G and 4G mobile broadband networks. Flurry, a company that provides app developers with tools to measure how much people use their apps, reports more than 1.3 trillion different app events each month.<sup>16</sup> App usage is driven by heavy consumer use of a wide variety of apps throughout the day including "productivity apps, games, lifestyle apps, social networking and more."<sup>17</sup> Not surprisingly, CTIA reports that overall U.S. wireless network data traffic increased by almost 70 percent between the end of 2011 and the end of 2012, to 1.468 trillion megabytes.<sup>18</sup>

All these data confirm that an increasing number of consumers have adopted a connected lifestyle in which 24/7 mobile broadband connectivity is expected — including when they are in

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<sup>14</sup> At the end of May 2013, there were reportedly 100 billion mobile applications installed on iOS and Android devices. "100 Billion App Downloads" (May 31, 2013) *available at* [http://www.asymco.com/2013/05/31/100\\_billion\\_app-downloads/](http://www.asymco.com/2013/05/31/100_billion_app-downloads/).

<sup>15</sup> *See, e.g.,* Shayndi Raice, "Facebook Flexes for Rivals - Social Network Touts New Partnerships, Features as it Gears Up for Competition," WALL STREET JOURNAL (Sept. 23, 2011) *available at* <http://online.wsj.com/article/SB10001424053111903703604576586992144487316.html>; *see also* Petition at 8 n.22 (noting that Facebook will be adding features that allow users to share music and entertainment programming with friends much like they share news stories, photos, and videos today).

<sup>16</sup> *See* Venture Beat ("According to Flurry's chief product officer..., the company now tracks 300,000 apps from 100,000 developers worldwide. Those apps are on one billion devices, giving Flurry data on more than three billion app "events" each day.").

<sup>17</sup> *Id.*

<sup>18</sup> *See* CTIA Survey.

a plane that is flying five miles above the surface of the earth. In fact, the ability of travelers to use devices while seated on an airplane in a quiet environment is likely to result in an increase in mobile broadband data usage when compared to such usage on the ground.

**C. Consumers Want And Deserve A High-Quality In-Flight Broadband Experience**

As the FCC Commissioners recognized when they approved the NPRM, the reality is that consumers “expect and often need to be able to get online 24/7, at home, in an office or on a plane.”<sup>19</sup> Indeed, “[t]oday’s airline passengers expect the same level of broadband service that is available on the ground.”<sup>20</sup>

Moreover, recent surveys confirm that “inflight Internet service is the number one enhancement that frequent flyers want when they fly” and with so much customer demand, “carriers that delay installation do so at considerable risk.”<sup>21</sup> In a recent survey, 40% of air travelers said that they had used the Internet on a flight in the last 12 months.<sup>22</sup> “The expectation of the traveler, especially the younger generation of travelers, is they can and should be able to remain connected anywhere at any time.”<sup>23</sup>

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<sup>19</sup> NPRM, Statement of Chairman Julius Genachowski.

<sup>20</sup> NPRM, Statement of Commissioner Mignon L. Clyburn. As Commissioner Rosenworcel noted “[t]he world does not wait for us to get off the plane.” NPRM, Statement of Commissioner Jessica Rosenworcel.

<sup>21</sup> About.com Aviation & Aerospace, “Airborne WiFi FAQs: Broadband Takes Flight”, available at <http://aviation.about.com/od/Airline-Finances/a/Airborne-Wifi-Faqs-Broadband-Takes-Flight.htm>.

<sup>22</sup> Bloomberg, “Netflix-Hungry Air Travelers Get Broadband Boost From FCC (May 9, 2013) available at <http://www.bloomberg.com/news/2013-05-09/netflix-hungry-air-travelers-get-broadband-boost-from-fcc.html>.

<sup>23</sup> *Id.* See also “Wi-Fi Tops In-Flight Entertainment Wish List: Research,” THE NATION (May 20, 2013).

Thus, airlines are adding Wi-Fi capability to aircraft used on short and long-haul flights,<sup>24</sup> and the number of planes equipped with Wi-Fi continues to increase.<sup>25</sup> It is not surprising that airlines are actively promoting the opportunity to “take your business above the ground.”<sup>26</sup> The market for in-flight broadband services is perceived as an attractive business opportunity and one that remains underserved.<sup>27</sup>

Accordingly, “the record before the [FCC] demonstrates a need to do more in order to satisfy consumer demand for quality inflight broadband service.”<sup>28</sup> Gogo, the current 800 MHz air-ground service licensee, concedes that “all providers of wireless connectivity services, including all providers of in-flight connectivity services, face certain limits on their ability to

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<sup>24</sup> See “2013 Travel Trends Include Increased Fees, Better WiFi, Higher Ethics, Consumer Corner, UPI (Jan. 2013) available at [http://www.upi.com/Business\\_News/Consumer-Corner/2013/01/20/Consumer-Corner-2013-travel-trends-include-increased-fees-better-WiFi-higher-ethics/UPI-75971358679660/](http://www.upi.com/Business_News/Consumer-Corner/2013/01/20/Consumer-Corner-2013-travel-trends-include-increased-fees-better-WiFi-higher-ethics/UPI-75971358679660/); “North America and Asia Compete for In-Flight Connectivity Top-Spot,” Satellite Today (June 7, 2013) (“[A]nalysts anticipate that as airlines include wireless content streaming and portable solutions on board in response to consumer demand, commercial airlines will spend \$900 million on [in-flight entertainment] by 2018, up from \$660 million in 2013. The research also suggests [ ] that more than 10,500 aircraft, or 57.5 percent of all planes in airline fleets, are currently equipped with at least one form of in-flight entertainment.”).

<sup>25</sup> “Slow Adoption of In-Flight WiFi Schools Airlines in What Works,” Travel Weekly, July 8, 2013, available at <http://www.travelweekly.com/Travel-News/Airline-News/Slow-adoption-of-in-flight-WiFi-schools-airlines-in-what-works/>; See Satellite Weekly (“In 2012, North America led all regions with 32 percent of the market share for [in-flight entertainment] content in aircraft....”).

<sup>26</sup> JetBlue is promoting this “stay connected inflight opportunity” See <http://www.jetblue.com/flying-on-jetblue/wifi/>. As the Commission is aware, the Qualcomm Petition was supported by the major U.S. airlines.

<sup>27</sup> Gogo noted that the number of scheduled passengers on commercial aircraft worldwide is expected to grow to 3.1 billion in 2013 and there is a “significant opportunity...to expand into this underserved market. Gogo, Inc., Prospectus, SEC Form 424B4 at 3, filed June 24, 2013 (“Gogo Prospectus”).

<sup>28</sup> NPRM, Statement of Commissioner Mignon L. Clyburn; see also Statement of Commissioner Jessica Rosenworcel (“Air travel stands out as one of the few places where we cannot always rely on a connection.”).

provide connectivity service, including escalating capacity constraints due to expanding consumption of wireless services and the increasing prevalence of higher bandwidth uses.”<sup>29</sup>

It is exactly those constraints and anticipated needs that Qualcomm’s proposal was intended to address. Qualcomm commends the FCC for initiating this proceeding. There is no question that the creation of the Air-Ground Mobile Broadband Service will “help meet consumer demand by offering airline passengers access to better in-flight broadband” and “enable business and leisure travelers aboard aircraft in the United States to be more productive and have more choices in entertainment, communications, and social media” while potentially lowering prices.<sup>30</sup>

## **II. The Proposed Air-Ground Mobile Broadband Service Can Successfully Operate On A Secondary Licensed Basis At 14.0 - 14.5 GHz**

Qualcomm’s strong support for the Commission’s proposal to establish a new terrestrial-based Air-Ground Mobile Broadband Service to aircraft in the 14.0 - 14.5 GHz band includes amending Part 2 of the Commission’s rules to add a secondary allocation in the non-Federal Aeronautical Mobile Service for air-ground mobile broadband service for the business and personal use of passengers aboard aircraft.<sup>31</sup>

Qualcomm agrees that a secondary allocation is appropriate for the Air-Ground Mobile Broadband Service because then it may not cause harmful interference to primary-status services, *see* 47 C.F.R. § 2.104(a)(1), and must accept any interference it receives from those services, *see* 47 C.F.R. § 2.104(a)(2). Primary-status services include Fixed Satellite Service (“FSS”) applications in the 14.0-14.5 GHz band, such as television distribution, satellite

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<sup>29</sup> Gogo SEC Filing at 17; *id.* at 19 (“[A]pplications and activities that require substantial bandwidth...are becoming increasingly common”).

<sup>30</sup> NPRM, Statement of Chairman Julius Genachowski.

<sup>31</sup> *See* NPRM at ¶¶ 2-8, 27.

newsgathering (“SNG”), business enterprise communications using Very Small Aperture Terminals (“VSAT”), direct to home satellite broadband and mobile applications like Earth Stations on Vessels (“ESV”), Vehicle-Mounted Earth Stations (“VMES”), and the newly created Earth Station Aboard Aircraft (“ESAA”) service.<sup>32</sup>

As detailed below, Qualcomm believes that there could be significant cost-savings and operational efficiencies by having one provider operate a single network using the entire 500 MHz allocation. Such a provider of this terrestrial-based service would still need to compete with satellite-based providers (*e.g.*, ESAA licensees) some of whom already hold Commission authorizations. On the other hand, there could be competitive benefits from two terrestrial-based networks. Qualcomm believes that the market ultimately should decide how many networks are viable. Therefore, while Qualcomm supports the FCC’s proposal to auction two licenses, we believe that the Commission should hold an open auction in which a single entity is permitted to buy both licenses, or two different entities can win the two licenses. In other words, the high bidder for each license should prevail, even if that means that one entity wins both licenses. Such an auction framework would best enable the free market to decide the structure of this new business.

Qualcomm strongly supports the FCC’s proposal to create nationwide licenses. Given that the nature of the service is to provide seamless broadband service to aircraft flying above the CONUS, it is imperative that the licenses to be auctioned be nationwide in scope.<sup>33</sup>

Qualcomm further agrees that the licenses (to the extent there are mutually exclusive applications) should be awarded by an auction conducted in accordance with the FCC’s general

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<sup>32</sup> See NPRM at ¶ 27.

<sup>33</sup> See NPRM at ¶ 5. Classifying the new service as CMRS is reasonable. *See id.*

competitive bidding rules in Part 1, Subpart Q. The Commission should issue Air-Ground Mobile Broadband Service licenses for a term of 10 years, but require licensees to demonstrate substantial service within five years given passengers' growing demand and airlines' concomitant need to meet that demand.<sup>34</sup> In the event that the Commission awards two licenses, the service rules should permit post-auction license assignments or transfers of control without restriction (other than the normal requirement of prior FCC approval) after the licensee meets the build-out requirements. Allowing post-auction license assignments or transfers of control before then would encourage spectrum speculators.

**A. The Proposed System Would Use Base Stations That Point North, Away From GSO Satellites Thousands Of Miles Above The Equator, And Thus Successfully Share Spectrum With These Primary FSS Users Of The Band**

All U.S.-based satellite systems that occupy the 14.0 - 14.5 GHz band are in Geostationary Orbit ("GSO") above the equator, and all ground-based satellite antennas in the U.S. that communicate with these satellites point southward towards one of the GSO satellites. The Air-Ground Mobile Broadband Service would place base stations at or near the southern points of hexagonal service areas, and the base station antennas would point north and limit emissions into the geo-arc to below a value to be specified in the Commission's rules.<sup>35</sup>

FCC rules will protect GSO satellites from harmful interference caused by Air-Ground Mobile Broadband Service aircraft transmitters by setting a maximum allowable emissions mask above the horizon, which limits emissions into the geo-arc. This is readily achievable because Air-Ground Mobile Broadband Service aircraft antennas would point down from the aircraft, below the horizon, and use lower transmit power than that from Air-Ground Mobile Broadband

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<sup>34</sup> See NPRM at ¶ 6.

<sup>35</sup> See NPRM at ¶ 19.

Service base stations, and thus provide an added means of protecting GSO FSS satellites from harmful interference. This system design, which includes high-gain base station smart antennas, coupled with beam steering, base station handoff, and intelligent assignment of operational frequencies, will mitigate interference from FSS earth stations into the Air-Ground Mobile Broadband Service base stations.<sup>36</sup>

Following two years of analysis and multiple rounds of comments, the Commission issued the NPRM, finding that Qualcomm provided “a substantial engineering analysis” and system design showing how an air-ground mobile broadband service can be successfully deployed in the 14.0-14.5 GHz band and how “potential interference can be mitigated.”<sup>37</sup>

**B. The Proposed Rules Will Enable An Air-Ground Mobile Broadband Service That Can Provide At Least 300 Gbps On A Combined Basis**

Qualcomm explained in its Petition that a single air-ground mobile broadband system operating in 500 MHz could support an aggregate throughput of 300 Gigabits per second (“Gbps”).<sup>38</sup> More specifically, the system Qualcomm designed to operate in accordance with the FCC’s proposed rules is based on the deployment of 150 base stations — with a maximum of four co-frequency beams each in a given swath of spectrum — to track up to 600 in-flight aircraft above the CONUS on the same piece of spectrum.<sup>39</sup> With 150 base stations, 4 co-frequency beams per base station, and 1 bps/Hz bandwidth efficiency (which Qualcomm believes is achievable based on the FCC’s proposed transmit power levels), 500 MHz of

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<sup>36</sup> See NPRM at ¶ 19 (citing Qualcomm Reply Comments on Petition at A4-A5).

<sup>37</sup> NPRM at ¶ 25.

<sup>38</sup> See Petition at 14. Qualcomm also noted that if the FCC allocates and auctions the spectrum in two separate 250 MHz blocks, the aggregate throughput for each system would be halved, to approximately 150 Gbps.

<sup>39</sup> The total number of aircraft that can be served simultaneously is much higher than 600; it is 600 times the number of frequency channels that the 500 MHz of spectrum is divided into.

spectrum can support a total forward link (“FL”) plus reverse link (“RL”) of throughput equal to ~300 Gbps on a combined basis.<sup>40</sup> If additional base stations are deployed or if additional beams are implemented, which may be necessary in high traffic areas, the aggregate throughput would increase while the interference to primary satellite operations would remain the same (or decrease).<sup>41</sup>

**C. Coordination Will Successfully Protect Other Incumbent Users Of The Band**

Qualcomm supports the FCC’s proposed regulations to protect the primary FSS users identified above and the proposed requirements that Air-Ground Mobile Broadband Service licensees coordinate their operations with Federal Fixed Service (“FS”) and Mobile Service (“MS”) licensees,<sup>42</sup> the National Aeronautics and Space Administration (“NASA”) Tracking and Data Relay Satellite System (“TDRSS”) in the 14.0 - 14.2 GHz band, and Radio Astronomy Service (RAS) users in the 14.47 - 14.50 GHz band.<sup>43</sup> Such coordination is consistent with and appropriate for a secondary allocation.

*FSS Applications.* Qualcomm supports the FCC implementing coordination requirements to protect incumbent operations in the 14.0-14.5 GHz band that are based on the requirements that the agency has adopted for mobile applications of the FSS, *e.g.*, for ESV, VMES, and

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<sup>40</sup> See Petition at A-8. In other words,  $150 \times 4 \times 500,000,000 \text{ Hz} \times 1 \text{ bps/Hz} = 300 \text{ Gbps}$  combined system throughput. The specific division of the transmission time between FL and RL and channelization of the available bandwidth will be determined based on operational needs; the interference calculations are unaffected so long as the EIRP for a given bandwidth is adjusted to maintain the FCC’s proposed power spectral density figure.

<sup>41</sup> See Qualcomm March 29, 2012, filing in RM-11640 (noting that if the number of cell sites is increased, the maximum transmit power from each cell site is reduced due to reduced path loss to the cell edge, which lessens the interference impact on satellites).

<sup>42</sup> See NPRM at ¶¶ 28, 45.

<sup>43</sup> See *id.* at ¶ 8; *id.* at ¶¶ 15, 29.

ESAA.<sup>44</sup> Qualcomm also appreciates the need to account for the fact that the Air-Ground Mobile Broadband Service will feature communications in both directions in the 14.0 - 14.5 GHz band between base stations and aircraft, in contrast to the FSS applications that use the band exclusively for unidirectional earth-to-space operations.<sup>45</sup>

*Space Research Service.* Qualcomm agrees with the need for the Air-Ground Mobile Broadband Service to coordinate operations with the Space Research Service at 14.0 - 14.2 GHz, specifically the TDRSS facilities in Guam and White Sands, New Mexico as well as the planned facility at Blossom Point in Maryland, through NTIA prior to commencing operations.<sup>46</sup> The process that the FCC's International Bureau has used for ESV, VMES and ESAA licensees to coordinate with NASA is a reasonable process that the Wireless Telecommunications Bureau should use with regard to the Air-Ground Mobile Broadband Service.<sup>47</sup>

*Radio Astronomy Service.* Similarly, as the Commission proposes, Air-Ground Mobile Broadband Service licensees operating in the 14.47 - 14.50 GHz sub-band within line of sight of Radio Astronomy sites should coordinate operations with the National Science Foundation prior to commencing operations.<sup>48</sup> Qualcomm agrees that the coordination agreements need to account for the fact that the Air-Ground Mobile Broadband Service licensee will be using the band for both uplink and downlink operations, which is more challenging than coordinating

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<sup>44</sup> See *id.* at ¶ 32.

<sup>45</sup> See *id.*

<sup>46</sup> See *id.* at ¶¶ 33-38.

<sup>47</sup> See *id.* at ¶ 36.

<sup>48</sup> See *id.* at ¶¶ 39-44.

operations with FSS users that use the band for unidirectional uplink communications exclusively.<sup>49</sup>

Additionally, Qualcomm supports the FCC's proposed modifications of footnote 133 to the U.S. Table of Frequency Allocations that apply the foregoing coordination requirements to the Air-Ground Mobile Broadband Service.<sup>50</sup>

### **III. Qualcomm Supports the Proposed Regulatory Framework For The New Service**

The Commission has the authority to create a new Aeronautical Mobile Service ("AMS") allocation in the 14.0 - 14.5 GHz band that complies with Section 303(y) of the Communications Act in order to provide "flexibility of use."<sup>51</sup> As detailed throughout the NPRM, the FCC's proposed creation of the Air-Ground Mobile Broadband Service on a secondary basis is in the public interest: It would spur technology development and investment in communications systems and services, and it would not cause or receive harmful interference from other users of the band. Furthermore, the proposed use is consistent with international agreements to which the United States is a party.<sup>52</sup>

For those reasons alone, Qualcomm supports the FCC's proposal to add a secondary allocation to the 14.0 - 14.5 GHz band only for AMS, and our company also supports the FCC's proposed service-specific rules to limit an AMS licensee's spectrum use to Air-Ground Mobile Broadband Services.<sup>53</sup> For example, and as the FCC notes, the identified band is not appropriate

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<sup>49</sup> See *id.* at ¶ 41. Qualcomm also supports filing of the coordination agreements via ULS. See *id.* at ¶ 43.

<sup>50</sup> See *id.* at ¶ 46.

<sup>51</sup> *Id.* at ¶ 47 (citing 47 U.S.C. § 303(y)).

<sup>52</sup> See *id.*

<sup>53</sup> See *id.* at ¶ 50.

for use by traditional terrestrial mobile services due to potential interference with incumbent users and poor propagation where there is ground clutter.<sup>54</sup>

**A. Air-Ground Mobile Broadband Service Rules Should Be In Part 22**

The Commission should regulate the new Air-Ground Mobile Broadband Service under Part 22 of its rules, as set out in its proposed rules in Appendix B of the NPRM.<sup>55</sup> This is consistent with how the FCC regulates the current 800 MHz air-ground service. The FCC also should permit an Air-Ground Mobile Broadband Service licensee to specify its regulatory status similar to the provisions found in FCC Rule Section 27.10. Qualcomm agrees that a prospective licensee would benefit from the flexibility of being able to choose between providing common carrier and non-common carrier services, or some combination of the two, and that licensees in the 14.0 - 14.5 GHz band be required to identify their regulatory status on FCC Form 601 and provide notice to the FCC of any change in that status within 30 days of such a change.<sup>56</sup>

**B. Qualcomm Supports The FCC's Proposed Licensing Rules And The Creation Of Two 250 MHz Licenses In The 14.0-14.5 GHz Band**

Qualcomm supports the Commission's proposal to adopt a licensing approach that allows the filing of mutually exclusive applications that, if acceptable, are resolved through an auction.<sup>57</sup>

1. The FCC Should Auction The Spectrum In Two 250 MHz Blocks

We support the FCC's proposal to auction the spectrum in two 250 MHz blocks that could enable the deployment of two separate air-ground mobile broadband systems.<sup>58</sup> Two

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<sup>54</sup> See *id.* at ¶¶ 49-51.

<sup>55</sup> See *id.* at ¶ 53, App. B.

<sup>56</sup> See *id.* at ¶¶ 54-55.

<sup>57</sup> See *id.* at ¶ 56.

<sup>58</sup> See *id.* at ¶¶ 58-61. Qualcomm also supports the FCC proposal to allow a single entity to hold both licenses for doing so could enable the deployment of a more robust service with

separate systems can operate in this spectrum — one at 14.0 - 14.25 GHz and the other at 14.25 - 14.5 GHz — and protect all incumbent users of the band, including TDRSS at the lower end of the band and Radio Astronomy users at the top end of the band, which operate in known geographic areas and in known frequency bands that can be avoided by the Air-Ground Mobile Broadband Service, as necessary.

As noted above, Qualcomm believes that there could well be significant cost savings and operational efficiencies from having the new service provided via a single terrestrial-based network using 500 MHz. Such a new terrestrial network would face competition from satellite-based systems. On the other hand, there could be competitive benefits from having two 250 MHz terrestrial-based networks. It is difficult at this early juncture to determine which market structure would be optimal. As a result, Qualcomm urges the Commission to auction two nationwide licenses, but to allow one entity to buy both authorizations. Conducting an open auction on this basis will allow the market to determine the best outcome.

Licensing the service to two licensees, each with rights to a separate 250 MHz block of spectrum, or a single licensee with rights to the full 500 MHz block of spectrum, will streamline the necessary coordination procedures with Federal FS and MS licensees, NASA TDRSS and RAS users, which are addressed in Section II.C above.<sup>59</sup> Having a limited number of Air-Ground Mobile Broadband Service licensees simplifies and thus improves interference remediation efforts in the unlikely event they are necessary.

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greater capacity. *See* NPRM at ¶ 69. As explained in Section II.B above, a system that operates in a 250 MHz wide block of spectrum can support a combined system throughput of at least 150 Gbps, while a system that operates in 500 MHz can support a combined system throughput of at least 300 Gbps.

<sup>59</sup> *See* NPRM at ¶ 61.

## 2. Nationwide Licenses Will Enable Rapid Deployment Of Air-Ground Services

The FCC should adopt a geographic licensing approach, as opposed to a site licensing scheme, because geographic licensing offers the necessary flexibility to more quickly respond to market conditions, such as the need to install additional base stations to provide increased capacity in high traffic regions of the country. In other words, a geographic approach reduces the regulatory burden and unnecessary transaction costs that site licensing would entail. Also, as the FCC notes, geographic area licensing is consistent with the agency's approach for many other mobile services.<sup>60</sup>

Air-Ground Mobile Broadband Service licenses should be issued on a nationwide basis, as previously noted, just like the existing 800 MHz air-ground service is licensed. Nationwide coverage is important because each Air-Ground Mobile Broadband Service licensee likely will want to provide service coast-to-coast service for both private and commercial aircraft that fly throughout the CONUS.<sup>61</sup> Defining smaller geographic service areas will only increase transaction costs for Air-Ground Mobile Broadband Service licensees who would then need to build nationwide license rights by securing multiple licenses that span the CONUS. Furthermore, without a nationwide license, service on cross country routes could be significantly delayed as some licensees may delay their build out until a post-auction consolidation process was completed.<sup>62</sup> Smaller service areas also will complicate equipment design and system

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<sup>60</sup> See *id.* at ¶ 62.

<sup>61</sup> See *id.* at ¶¶ 64-65.

<sup>62</sup> Negotiating roaming agreements between operators in different geographic areas would be time consuming and expensive and significantly delay the rollout of the service. As the FCC knows, even terrestrial cellular networks strive to build nationwide networks where users travel between geographic areas at much slower rates than aircraft.

operations to the extent a service provider is authorized to operate in the lower 250 MHz block of spectrum in some areas of the country and the upper 250 MHz in other areas.

There are other technical reasons to issue nationwide licenses. Since aircraft fly at high altitudes and air-to-ground signal propagation follows a free space propagation model, the signal from aircraft on one network may interfere with base stations in adjacent geographic areas if the two networks are run by different operators. In fact, Air-Ground Mobile Broadband Service licensees deploying TDD operations that use the same swath of spectrum in adjacent geographic areas would need to be carefully synchronized to avoid interference between their systems. Finally, allocating licenses on a non-nationwide basis could lead to undue fragmentation and result in deployment delays. Nationwide licenses will enable the far more rapid deployment that is necessary to service the expanding demand for in-flight broadband connectivity that airlines are experiencing.

### 3. Qualcomm Supports The Commission's Foreign Ownership And Spectrum Aggregation Proposals

With regard to foreign ownership reporting requirements, Qualcomm agrees with the FCC that all applicants for licenses should be required to provide the same ownership information and enjoy flexible application requirements so long as they comply with Sections 310(a) and 310(b) of the Communications Act.<sup>63</sup> Qualcomm also agrees that the Commission should adopt an open eligibility standard for potential license applicants because it encourages efficient use of the spectrum, supports rollout of new technologies, products, and services, and is consistent with FCC practice for other mobile wireless spectrum allocations.<sup>64</sup>

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<sup>63</sup> See NPRM at ¶ 66.

<sup>64</sup> See *id.* at ¶ 67.

In addition, Qualcomm supports the Commission's proposal to not adopt spectrum aggregation limits with regard to the licensing of this band.<sup>65</sup> As noted above, to the extent the FCC establishes two 250 MHz spectrum licenses, Qualcomm supports the proposal to allow a single entity to acquire both blocks of spectrum to enable the construction of a single, higher capacity, and potentially more robust, 500 MHz system.<sup>66</sup>

4. Qualcomm Also Supports The FCC's Proposed License Term And Renewal Criteria Regulations, But A Five Year Build-out Rule Will Spur The Rapid Deployment Of Air-Ground Broadband Connectivity

Qualcomm agrees that a ten year license term is appropriate for the Air-Ground Mobile Broadband Service, which is the same license term that the agency has instituted for most other wireless services, including the existing 800 MHz air-ground service.<sup>67</sup> Qualcomm also supports the Commission's proposed license renewal criteria, which are modeled on the three criteria the agency implemented for the 700 MHz band licenses, that is: (1) renewal applicants must file a detailed renewal showing, demonstrating that they are providing service to the public (or, are using the spectrum for private, internal communication to the extent permitted by the Commission), and substantially complying with the Commission's rules (including any applicable performance requirements); (2) competing renewal applications are prohibited; and (3) if a license is not renewed, the associated spectrum is returned for reassignment by the FCC.<sup>68</sup>

With regard to licensee performance requirements, Qualcomm encourages the FCC to implement a five-year substantial service requirement, instead of the ten-year requirement the NPRM proposes, for the same reasons the Commission relied upon when it instituted a five year

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<sup>65</sup> See *id.* at ¶ 68.

<sup>66</sup> See *id.* at ¶ 68-69.

<sup>67</sup> See *id.* at ¶ 71.

<sup>68</sup> See *id.* at ¶ 81.

substantial service requirement for the current 800 MHz air-ground service. A five-year substantial service requirement will encourage the timely and much-needed deployment of Air-Ground Mobile Broadband Service and investment in the new technology; it also will prevent warehousing of spectrum, which would be completely contrary to the public interest.<sup>69</sup>

Qualcomm encourages the Commission to incorporate into the Air-Ground Mobile Broadband Service the following substantial service definition, consistent with the Communications Act, *i.e.*, “service that is sound, favorable, and substantially above a level of mediocre service that would barely warrant renewal.”<sup>70</sup> Qualcomm further supports the FCC’s proposed “safe harbor” to meet that standard.<sup>71</sup> Qualcomm agrees that licensees should be required to file a notification within 15 days of the five-year benchmark stating that they have met the applicable performance requirement, and that the construction notification include maps and other information that are necessary to confirm compliance with the requirement.<sup>72</sup> Qualcomm further agrees with the application of Section 1.946(c) procedures in the event substantial service is not timely initiated.<sup>73</sup>

Qualcomm supports the Commission’s proposed standard for “permanent discontinuance” of the Air-Ground Mobile Broadband Service, that is, service will be deemed to be permanently discontinued if the licensee is not providing service to aircraft or subscribers for 180 consecutive days.<sup>74</sup> In addition, the FCC should permit partitioning and disaggregation of an Air-Ground Mobile Broadband license only after the licensee meets the build-out requirements

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<sup>69</sup> See *id.* at ¶ 74.

<sup>70</sup> See *id.* at ¶ 74 (citing 47 U.S.C. § 309(j)(4)(B)).

<sup>71</sup> See *id.* App. B, proposed rule § 22.1113(b)(1).

<sup>72</sup> See *id.* at ¶ 81.

<sup>73</sup> See *id.* at ¶ 80.

<sup>74</sup> See *id.* at ¶ 85.

as to the geographic area or spectrum that it seeks to maintain.<sup>75</sup> Qualcomm also supports application of the Commission’s general spectrum leasing rules and policies to the Air-Ground Mobile Broadband Service.<sup>76</sup>

As noted above, should the Commission award two Air-Ground Mobile Broadband Service licenses, there should be no restriction on post-auction license assignments or transfers of control (except for obtaining normal required FCC approvals) — once a licensee meets the build-out requirements. Permitting post-auction license assignments or transfers of control without having to comply with the construction requirement certainly could encourage spectrum speculators.

**C. The FCC’s Competitive Part 1 Bidding Rules Should Be Applied Here**

Qualcomm agrees that the competitive bidding rules in Part 1, Subpart Q of the Commission’s rules should apply to any auction the agency conducts for purposes of awarding Air-Ground Mobile Broadband Service licenses.<sup>77</sup> Part 1 appropriately delegates authority to the Wireless Telecommunications Bureau to determine various auction specific measures, such as minimum opening bids and auction design.

The Commission proposes to make small business bidding credits available for the Air-Ground Mobile Broadband Service auction.<sup>78</sup> As the NPRM notes, in the past, where other nationwide services were involved, it has declined to adopt provisions for bidding credits. Further, the FCC acknowledges that the legislative history of Section 390(j) of the Act

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<sup>75</sup> See *id.* at ¶ 89.

<sup>76</sup> See *id.* at ¶¶ 90-91.

<sup>77</sup> See *id.* at ¶ 95.

<sup>78</sup> See *id.* at ¶¶ 96-100.

demonstrates that Congress did not necessarily intend that the Commission adopt such special measures in the case of nationwide services.<sup>79</sup>

Qualcomm agrees that the costs of deploying and operating a nationwide air-ground mobile broadband system may require relatively lower capital expenditures as compared to satellite-based aircraft communications systems.<sup>80</sup> However, the cost to deploy a nationwide service will be substantially more than the average annual gross revenue amounts that the Small Business Administration, and by extension, the FCC, use to define a small business (\$40 million average annual gross revenue) and a very small business (\$15 million average annual gross revenue).<sup>81</sup> Thus, it is doubtful that a very small business or a small business can successfully deploy and operate a nationwide air-ground mobile broadband system from a financial perspective. For purposes of reference, the current air-ground service licensee, Gogo, has average annual revenues well in excess both these amounts.<sup>82</sup>

In light of the foregoing, Qualcomm submits that the nationwide basis for the service, as well as the presence of existing competitors using satellite-based operations, argue against the use of bidding credits. In this context, there are legitimate doubts that such credits are necessary “in order to promote the [statutory] objectives of . . . ensuring that new and innovative technologies are readily accessible to the American people and the dissemination of licenses

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<sup>79</sup> See *id.* at ¶ 97 citing House Report that “[t]he characteristics of some services are inherently national in scope , and are therefore ill-suited for small businesses.” *Id.* at ¶ 98, n. 155.

<sup>80</sup> See *id.*

<sup>81</sup> See *id.* at ¶ 98.

<sup>82</sup> See Gogo Prospectus at 57.

among a wide variety of applicants.”<sup>83</sup> Thus, Qualcomm respectfully submits that there is no sound basis to apply bidding credits for small or very small businesses for this unique auction.

#### **IV. Qualcomm Supports The Commission’s Proposed Technical Operating Rules**

It should come as no surprise that Qualcomm strongly supports the Commission’s proposed technical rules for the Air-Ground Mobile Broadband Service, for they are based in large part on the proposals in Qualcomm’s Petition and were supported with extensive technical submissions.<sup>84</sup> Indeed, Qualcomm presented multiple detailed analyses of how a proposed Air-Ground Mobile Broadband Service could successfully share spectrum and operate in a band currently occupied by primary FSS operations and other incumbent users and developed a technically viable air-ground network plan that could be successfully deployed in the 14.0 - 14.5 GHz band.

Qualcomm also showed that the Air-Ground Mobile Broadband Service parameters it used very conservative parameters to demonstrate that the proposed system can operate on an interference-free basis with incumbent users of the band. For example, for purposes of developing the proposed rules, the base station antenna roll-off front to back ratio was assumed to be -37 dB, but Qualcomm’s prototype base station antenna was measured to have a front-to-back ratio of at least -50 dB.<sup>85</sup> Thus, the technical parameters that the FCC used to develop its

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<sup>83</sup> See *Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band, Report and Order, Memorandum Opinion and Order and Further Notice of Proposed Rulemaking*, 12 FCC Rcd 5754, 5825 , ¶176 (1997).

<sup>84</sup> See NPRM at ¶ 101 n.161; *id.* at ¶ 102; Qualcomm filings in RM-11640. See also NPRM, App. B – Proposed Rules. Qualcomm offers a few minor modifications to the FCC’s proposed regulations, as described in these comments.

<sup>85</sup> See, e.g., Qualcomm filing in RM-11640 (Oct. 2, 2012).

technical rules,<sup>86</sup> which are based on Qualcomm's Petition, are quite conservative. The actual performance of the system will present substantially less interference than calculated.

**A. The Proposed Technical Rules Will Protect GSO Satellite Systems And Future NGSO Satellite Systems From Harmful Interference**

Qualcomm's detailed technical submissions in RM-11640 demonstrated how the proposed service can operate without causing interference to GSO satellite systems and future potential NGSO satellite systems. Qualcomm submits that the FCC should set the allowable  $\Delta T/T$  (or Rise over Thermal -"RoT") for GSO systems at 1% based upon technical parameters set out in Table 1 of the NPRM, which actually ensure that the actual  $\Delta T/T$  remains well below 1% during typical operation.<sup>87</sup>

Regarding the issue of how high the average G/T of a CONUS beam can be for a high performing satellite, Qualcomm demonstrates below that the limit is less than 4.5 dB, even with a high performing antenna and Low-Noise Amplifiers ("LNAs").<sup>88</sup> Table 1 below shows the computation of the average G/T over the CONUS for a high performing CONUS beam. Table 1 accounts for the distance from the GSO location to the center of the CONUS rather than to the equator, and it also accounts for the fact that the CONUS area is tilted by about 45° with respect to the GSO location. Table 1 below computes the angle subtended from GSO location to a circular area equivalent to the area of the CONUS while accounting for the proper distance and angle from the GSO location to the CONUS. The calculations in Table 1 assume an 80%

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<sup>86</sup> See NPRM at ¶ 102, Table 1. Qualcomm based its proposal on a TDD system because it is not possible to build a viable duplexer with a 250 MHz or 500 MHz-wide bandwidth for operations at 14 GHz; thus, an FDD system is not commercially feasible in the proposed band. See NPRM at ¶ 101.

<sup>87</sup> As discussed, *infra*, Qualcomm also recommends that the FCC impose a 6%  $\Delta T/T$  (or RoT) level for NGSO satellite operations.

<sup>88</sup> See NPRM at ¶¶ 102-04.

antenna efficiency for the satellite antenna, which corresponds to a high performing beam. Table 1 below also assumes that the LNA noise temperature is 50 degrees Kelvin, which also should correspond to a high performing LNA.

**Average G/T of a CONUS Beam**

CONUS area	9827000.00	km <sup>2</sup>
CONUS tilt relative GEO location	45.00	Degree
CONUS area corrected for tilt (cos(45))	6948738.34	km <sup>2</sup>
Distance from GEO satellite to center of CONUS	37800.00	km
Angle of equivalent circular area subtended from satellite toward CONUS	4.51	Degree
Peak gain of antenna illuminating the equivalent tilted area	33.05	dBi @ 100% antenna eff.
Average gain of the antenna over CONUS (-1.5 dB)	31.55	dBi @ 100% antenna eff.
RF antenna feed line loss	-1.00	dB
Net antenna gain (100% antenna efficiency)	30.55	dBi @ 100% antenna eff.
Net antenna gain (80% antenna efficiency)	29.58	dBi @ 80% antenna eff.
Antenna & earth ambient noise temperature	290.00	K
High performing LNA noise temperature	50.00	K
Total system temperature	340.00	K
G/T for 80% antenna efficiency	4.26	dB/K

**Table 1.** Average G/T of a high-performing CONUS beam

Note that even with idealistic assumptions of LNA noise temperature of 25 degrees Kelvin, feed line loss of 0.5 dB, and antenna efficiency of 90%, the average G/T would be approximately 5.6 dB/K. In other words, even under the most optimistic parameters, the average G/T over the CONUS is less than 6 dB/K. Table 1 shows that for a high performing beam the average G/T is most likely around 4 dB. If the G/T exceeds 4 dB/K, then the satellite beam is very likely a regional beam that does not cover all of the CONUS evenly and does not see all the Air-Ground Mobile Broadband Service base stations or aircraft at the same G/T. So, as the G/T is increased regionally, it must be decreased in other areas.

In sum, Qualcomm agrees that the average G/T of CONUS beams of some newer satellites may be higher than the 2 dB/K used in Qualcomm's baseline calculations. Based on the analysis shown in Table 1 above, Qualcomm believes that an average G/T of 4 dB should be specified for the emissions limits for CONUS beams into GEO arc. Alternatively, the FCC can request a G/T map of high performing satellites so that it may determine an appropriate value via an averaging of the G/T map.

**B. Protection Of TDRSS And RAS Sites Will Be Accomplished Through Network Planning And Coordination Agreements**

TDRSS and RAS sites will be protected from interference from Air-Ground Mobile Broadband Service operations by careful network planning, such as restricting Air-Ground Mobile Broadband Service base stations within 70 km of TDRSS sites from operating in the 14.00 - 14.05 GHz portion of the band and similarly avoiding operations that could interfere with RAS, and by entering into coordination agreements with NASA and RAS operators.<sup>89</sup>

**C. The Southernmost Base Stations Need Not Be Treated Any Differently From The Other More Northerly Air-Ground Mobile Broadband Base Stations**

The southernmost Air-Ground Mobile Broadband Service base stations will operate with low transmit power and at low elevation angles but they need not be treated any differently from the more northerly base stations in order to prevent harmful interference into the geo-arc.<sup>90</sup> In fact, the transmit power levels of the southernmost Air-Ground Mobile Broadband Service base stations do not need to be reduced as a function of elevation any differently than the other more

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<sup>89</sup> See NPRM at ¶¶ 106-109.

<sup>90</sup> See *id.* at ¶ 110. Qualcomm explained in the Petition that the southernmost row of GSs, aircraft flying at azimuth angles greater than  $\pm 60^\circ$  from the GS will be served by the nearest GS, but the EIRP of the serving beam will be reduced so as to meet the requirement of not interfering with the geo-arc; in this case, the data rate to aircraft very close to the southern border may need to be reduced. However, by allocating greater transmission time to these planes, adequate throughput to the planes can be maintained. See Petition at A-4; see also *id.* at 16.

northerly sites over the CONUS in order to avoid interference into the geo-arc. With regard to NGSO satellites, however, which may be at elevation angles as low as 20° above the horizon within the perspective of an Air-Ground Mobile Broadband base station, the base station uses an isoflux antenna (where the antenna gain is reduced in proportion to the distance between the plane and the base station) to avoid interfering with NGSO satellites, as Qualcomm explained in the Petition.<sup>91</sup>

**D. The FCC Should Define A 1% Aggregate  $\Delta T/T$  For The Proposed Service Into GSO Satellite Operations**

The Commission should define an aggregate  $\Delta T/T$  of 1% for the Air-Ground Mobile Broadband Service into GSO satellite operations, recognizing that the proposed service will not come close to the 1% level given the transmit power requirements that the agency proposes to impose on the licensees.

Qualcomm supports the FCC's proposed regulation that the aggregate EIRP density into the GSO arc from all beams not exceed -46.7 dBW/Hz and that the EIRP density from a single beam into the GSO arc must be less than -74.5 dBW/Hz, based upon a total of 600 beams (*i.e.*, 150 base stations with four beams each). And, if the licensee increases the number of base stations from 150 to 250, EIRP density from a single beam into any point in the GSO arc must be proportionately reduced to -76.7 dBW/Hz.<sup>92</sup> Thus, Equation (1) in proposed Rule 22.1120(a) is appropriate as it lowers the emission from an airplane or base station into the geo-arc where the number of base stations is increased beyond 150. However, the aggregate EIRP density into any point in the geo arc needs to remain the same, *i.e.*, at -46.7 dBW/Hz. Only the per beam level needs to be reduced in order to keep the aggregate EIRP below -46.7 dBW/Hz — independent of

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<sup>91</sup> See Petition at A-25 to A-27.

<sup>92</sup> See NPRM, App. B, Proposed Rule Section 22.1120(a).

the number of base station beams or aircraft.<sup>93</sup> Moreover, the foregoing power levels resulted in  $\Delta T/T$  of 0.5%, which provides additional margin of interference protection for GSO satellite operations. Thus, there is no question that the FCC's proposed requirements will fully protect GSO FSS operations from harmful interference.

Also, because it is highly unlikely that all Air-Ground Mobile Broadband Service base stations will operate at the same levels simultaneously, the FCC should afford these secondary licensees the flexibility to distribute the power density of base stations according to traffic patterns and to optimize coordination with other, co-secondary, 14.0-14.5 GHz licensees.<sup>94</sup>

**E. Aggregate And Individual Aircraft Antenna Power Limits Are Appropriate**

Qualcomm explained that its interference calculations were based on worst-case assessments and still demonstrated that the Air-Ground Mobile Broadband Service aircraft transmitters will operate with a  $\Delta T/T$  that is less than 1%.<sup>95</sup>

Qualcomm agrees that the emissions from all aircraft into the geo-arc should be limited to -47 dBW/Hz, which corresponds to a  $\Delta T/T$  of 0.5% for satellite G/T of 2 dB. Qualcomm also agrees that a maximum emissions limit from an aircraft into the geo-arc should be defined once a G/T value is defined. Qualcomm, in its analysis of  $\Delta T/T$  (or RoT) in Section 3.3.1.2 of the Petition, took a 5° aircraft roll into account.<sup>96</sup> Therefore, FCC rules should set an aggregate emissions level and an individual aircraft emission level into the geo-arc, and operators would be

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<sup>93</sup> Thus, Equation (2) in proposed Rule 22.1120(a) is not appropriate and should be removed from the proposed rule because the aggregate emission level should remain the same. As long as the aggregate emission level into the geo-arc remains below -46.7 dBW/Hz, then independent of the number of airplanes or base stations, the RoT will be below 0.5 % based upon the assumptions in Table 1 of the NPRM.

<sup>94</sup> See *id.* at ¶ 112.

<sup>95</sup> See *id.* at ¶¶ 113-14.

<sup>96</sup> See Petition at A-20.

required to design their system so that it meets both limits in the presence of aircraft roll. Qualcomm agrees that when aircraft roll is more than  $5^\circ$ , and the aircraft transmit power is required to be reduced to a point where a connection between the aircraft and the serving base station cannot be maintained, the aircraft transmitter must be turned off.<sup>97</sup> In other words, limiting single aircraft emissions into the geo-arc accounts for this and forces the aircraft transmitter to turn off at high roll angles. The specification of total and single aircraft emissions into the geo-arc has the advantages of being technology independent and offering system operators design flexibility.

Proposed FCC Rule Section 22.1120(b) states that the EIRP from each plane should be limited to 3 dBW per 2 MHz. Qualcomm respectfully requests that instead of limiting the EIRP from each plane in this way, the FCC should define the per-plane emissions level the same way it proposes to define the base station EIRP level. Such an approach is technology independent and provides increased flexibility to technology developers and system operators. In fact, there is no need to specify the EIRP from a plane once a per plane emission level into the geo-arc is specified. In order to maintain an RoT level into the geo-arc below 0.5%, per the assumptions of in Table 1 of the NPRM, the aggregate emission level from all planes into the geo-arc must be below -46.7 dBW/Hz. Thus, instead of specifying per plane EIRP as 3 dBW per 2 MHz per plane, the Commission should set a per-plane level of -74.5 dBW/Hz, which is obtained by dividing the total allowable emission level into the geo-arc, -47.6 dBW, by 600 planes to arrive at -74.5 dBW/Hz; this is the same level that is allowed by one base station beam in proposed Rule Section 22.1120(a). Thus, Qualcomm recommends that Equation (1) in proposed FCC

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<sup>97</sup> Qualcomm thus recommends that the FCC specify (perhaps in proposed Rule Section 22.1120), that the per-plane emission into geo-arc of -74.5 dBW/Hz shall be maintained where the plane rolls.

Rule Section 22.1120(a) be applied to the per plane emission level for cases where the number of base stations is increased beyond 150. In other words, the rule governing the total allowed emission from all base stations into the geo-arc and per base station emission level into the geo-arc should be applied to the aircraft.

**F. The FCC Should Allow Increased Power To Compensate For Rain Fade**

Qualcomm agrees that the FCC should permit Air-Ground Mobile Broadband Service base stations to increase power up to 6 dB to compensate for rain fade when the EIRP density to the GSO arc from an individual base station is less than -68.5 dBW/Hz for an Air-Ground Mobile Broadband system with 150 base stations.<sup>98</sup> With regard to whether the additional power for beams affected by rain should come from powering down other beams or turning off some beams, Qualcomm proposes powering down other beams, for the reasons explained below.

The following calculation shows that lowering power for some beams to compensate for a beam using higher power to compensate for rain fade is more bandwidth efficient than turning beams off. Consider four beams operating with equivalent EIRP. To increase the EIRP of one beam by 3 dB while keeping the total EIRP from the four beams constant, one of two approaches is possible: (i) one of the four beams may be turned off; or (ii) all of the beams may remain on but the EIRP of the three other beams is reduced by 33% (*i.e.*, lowered by 1.76 dB) to maintain the same total EIRP. If one assumes that each beam had 25% of the total capacity and one of the four beams is turned off, then the capacity of the four beams is reduced to 75% of the pre-power control capacity. If, however, all four beams remain on but the EIRP of three of the beams is reduced by 1.76 dB, then assuming operations at 7 dB C/N and using the Shannon bandwidth efficiency bound of  $(\log_2(1 + \frac{C}{N}))$ , the total capacity is only reduced to about 86% of the pre

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<sup>98</sup> See NPRM at ¶ 115.

power control capacity. This result is due to a simple application of the Shannon bound equation, that is, bandwidth efficiency is non-linear function of C/N.

Thus, reducing the power of some beams to account for an increase in EIRP for other beams to compensate for rain fade, while maintaining the same total emission level into the geo arc, is a more bandwidth efficient approach than completely turning off beams. Qualcomm respectfully requests that proposed Rule Section 22.1120(c) be modified to permit the use of power control so long as the total emission level remains below -46.7 dBW/Hz when the power of some beams is increased to compensate for rain. As explained above, it is not necessary to reduce the number of beams used in order to maintain the same maximum transmitted power.

**G. The FCC Should Set A 6% Aggregate  $\Delta T/T$  For NGSO Satellites Rather Than Set An Off-Axis EIRP Density In Directions Other Than Along The GSO Arc**

The FCC asks what standards, if any, it should adopt for off-axis EIRP density in directions other than the GSO arc, and specifically asks whether it should require the Air-Ground Mobile Broadband Service transmitter to turn off if an NGSO satellite is in its line of sight.<sup>99</sup>

For NGSO systems, Qualcomm used an RoT of 6% because NGSO systems do not exist in the 14.0 - 14.5 GHz band today, and Qualcomm believes that these systems can be designed in the future to cope with a 6% RoT level that existing systems are required to meet.<sup>100</sup> Qualcomm showed that, even in this case, baseline system assumptions of the Air-Ground Mobile Broadband system led to an RoT below 1% from Air-Ground Mobile Broadband Service

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<sup>99</sup> See *id.* at ¶ 116.

<sup>100</sup> See Petition at A-11 (“The values given for the target RoT ... are thresholds for coordination given in Table 5.1 of Appendix 5 of the Radio Regulations.”).

equipped aircraft into NGSO satellites and below 1% from Air-Ground Mobile Broadband Service base stations into NGSO satellites.<sup>101</sup>

In Section 3.3.2 of the Petition, Qualcomm computed the  $\Delta T/T$ , or RoT, into a high performing NGSO satellite with a G/T of -7 dB/K, 50 beams, and an altitude of 1000 km. Qualcomm showed that the RoT into the NGSO satellite can be met at a level that is well below the 6% level, which was the target in Table A.3 of the Petition. As Qualcomm has explained, the Air-Ground Mobile Broadband Service base station EIRP is reduced at higher elevation angles according to an isoflux antenna pattern as the distance between the aircraft and the base station is reduced. Because the base station antenna is aimed at low elevation angles (where most planes will be flying), the antenna will have lower gain at higher elevation angles. So, instead of specifying an emission mask at this time — before any NGSO satellites are operating in this band — Qualcomm recommends that the FCC set a 6 % RoT into NSGO satellites, which is the level it used in the Petition. This approach requires the Air-Ground Mobile Broadband Service operator to meet the limit by implementing an appropriate antenna design and/or turning off transmissions to meet the limit, and it avoids a technology-specific design. Moreover, a 6% RoT into NGSO satellites is reasonable as any future NGSO system will use the latest error correction technology and should be able to accept an RoT of 6% without a loss of data rate and with negligible additional cost. The difference between handling a 1% versus a 6% RoT to an NGSO satellite is ~0.2 dB, which could be compensated (if so desired) by allowing the NGSO earth stations to use 0.2 dB greater EIRP, which is a negligible additional cost. On the other hand, in terms of performance, a 0.2 dB loss of C/N at the NGSO satellite results in negligible capacity loss in modern communication systems. For instance, at 7 dB C/N, the band efficiency using

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<sup>101</sup> See Petition at A-11, A-25 to A-27, and A-42.

Shannon capacity bound  $\log_2(1 + \frac{C}{N})$ , is  $\log_2(1 + 10^{0.7})$  which is  $\sim 2.59$  bits per second per Hz versus  $\log_2(1 + 10^{0.68})$  which is  $\sim 2.53$  bits per second per Hz, *i.e.*, only a 2% difference. In fact, since any future NGSO system will experience inter-beam interference, a 6% RoT will have even a smaller impact to the  $C/(I+N)$  seen by the NGSO receiver.

#### **H. Out-Of-Band Emissions Limits To Protect Two Adjacent Air-Ground Systems**

Qualcomm agrees that an out-of-band emissions requirement is necessary to protect emissions from one Air-Ground Mobile Broadband system from interfering with an adjacent system (to the extent two different entities each hold one of the two Air Ground Mobile Broadband Service licenses) and supports the Commission’s proposed regulation that the power level of any emission outside either licensee’s own frequency band shall be attenuated below  $43 + 10 \cdot \log(P)$  dB when measured 1 MHz from the edges of the licensee’s authorized band.<sup>102</sup>

#### **I. Addressing Interference Into Air-Ground Mobile Broadband Service Operations**

Qualcomm strongly believes that the proposed Air-Ground Mobile Broadband Service will operate successfully in the presence of potential interference from primary FSS users as its detailed technical filings in RM-11640 demonstrate. The FCC need not impose any “robustness requirements” upon Air-Ground Mobile Broadband Service licensees. The market for robust broadband service to aircraft via terrestrial-based and satellite-based systems will ensure that the Air-Ground Mobile Broadband Service is robust and reliable.<sup>103</sup>

#### **J. Regulation Of Operations On U.S. and Non-U.S. Registered Aircraft**

Qualcomm agrees that any Air-Ground Mobile Broadband Service-equipped aircraft whose flight path takes it outside the CONUS should terminate operations and that operations in

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<sup>102</sup> See NPRM at ¶ 117.

<sup>103</sup> See *id.* at ¶ 118.

Canadian airspace should not be permitted unless and until the Canadian government permits aircraft in Canadian airspace to use the system that the FCC proposes to permit.<sup>104</sup>

Qualcomm also supports the FCC's proposal to allow non-U.S., registered aircraft to contract with Air-Ground Mobile Broadband Service licensees for equipment and services when such aircraft are flying above the CONUS.<sup>105</sup>

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<sup>104</sup> *See id.* at ¶ 119.

<sup>105</sup> *See id.* at ¶ 123.

**CONCLUSION**

Qualcomm respectfully requests that the Commission promptly issue a Report and Order authorizing the service proposed in the Air-Ground Mobile Broadband NPRM in accordance with the foregoing comments. Qualcomm looks forward to helping enable multi-gigabit-per-second Air-Ground Mobile Broadband Services that are needed now to support the exploding usage of mobile broadband devices, applications, and services on in-flight aircraft well into the future.

Respectfully submitted,

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