QUALCOMM Incorporated
1730 Pennsylvania Ave., NW ■ Suite 850 ■ Washington, DC 20006 ■ Tel: 202.263.0020 www.qualcomm.com

January 30, 2012

James Ball
International Bureau
Chief – Policy Division
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Petition for Rulemaking To Establish A Next Generation Air-Ground Service On A Secondary Licensed Basis In The 14.0 to 14.5 GHz Band, RM-11640

Dear Mr. Ball:

QUALCOMM Incorporated ("Qualcomm") is pleased to respond to the technical questions that the International Bureau staff posed in its January 19, 2012, letter relating to the above-referenced Petition for Rulemaking. Our responses are provided in the five-page attachment to this cover letter.

Qualcomm looks forward to continuing to work with the FCC and all interested stakeholders to advance the proposals set forth in the Petition for Rulemaking. Qualcomm has invested significant resources developing next generation air-ground broadband technology, and the company is prepared to invest in and support the deployment and operation of a highly robust network to enable such broadband connectivity. Qualcomm encourages the FCC to issue a Notice of Proposed Rulemaking very soon proposing to establish the Next Generation Air-Ground service on a secondary licensed basis in the 14.0-14.5 GHz band so that the proposed service can become a reality.

Respectfully submitted,

Dean R. Brenner
Vice President, Government Affairs

Att.

cc (via email): Kathleen Collins
Howard Griboff
Paul Locke
Robert Nelson

Attachment – Qualcomm Responses to Staff's Technical Questions

(1) We understand your analysis assumes an even distribution of aircraft over the United States, suggesting that the results of your analysis are independent of the beamwidth of the Fixed Satellite Service (FSS) satellite antenna. That is, as the FSS satellite antenna beamwidth decreases and its sensitivity increases, there will be correspondingly fewer aircraft within the beam, so the levels of interference will remain constant. However, given that the distribution of aircraft is not uniform and the number of aircraft per square mile can be significantly higher over certain airports, how will you compensate for this uneven aircraft distribution to ensure no FSS satellite receiver will receive more than the calculated interference?

Response:

Qualcomm believes that cell splitting, that is, increasing the density of Next Generation Air-Ground ("Next-Gen AG") Ground Stations ("GSs") to provide higher capacity, may be necessary in high traffic areas. In areas with an increased concentration of GSs, however, a reduction of transmit power from the GS and aircraft may be necessary so the total EIRP into the orbital arc remains the same.

For example, suppose the number of sites in one region of the country is doubled. Since the area of a hexagon (*i.e.*, the service area described in Appendix A of the Petition) is proportional to square of the cell radius and free space propagation is also proportional to the square of distance, the transmit EIRP of the GS and aircraft in this area can be reduced by the same amount as the increase in the number of sites without impacting coverage. If the number of sites is doubled, then the diameter of each hexagonal site is reduced by a factor of $\sqrt{2}$; and, the maximum path loss at the cell edge is reduced by square of the cell diameter, that is, by a factor 2. Thus, the transmit EIRP within the smaller cells would be reduced by 3 dB.

The Next-Gen AG network was designed to provide coverage over the CONUS. As stated in the Petition, Qualcomm estimates that a minimum of 150 sites would be needed to provide such coverage. However, the initial network design may require additional sites to cover specific areas of the CONUS that a linear layout of cells does not cover. Qualcomm estimates that, at most, 10 additional sites (for a total 160 sites) would offer full coverage. Ultimately, additional sites may be deployed to provide more capacity in high traffic areas, such as the East and West Coasts, potentially resulting in as many as 250 sites for a mature network. However, as noted above, as a cell is sub-divided into two new cells, the maximum EIRP of the GS beams and aircraft will be reduced by 3 dB resulting in the same total EIRP as the baseline system set out in the Petition. Thus, there will be no interference impact from these additional sites.

(2) Your analysis appears to assume that the satellite beams are non-overlapping. In reality, however, there is some out-of-beam energy collected by a satellite antenna. How will this additional interference affect the interference analysis you have provided?

Response:

The calculations of the interference received by a satellite beam use the average G/T of the satellite beam, where the averaging of the G/T was performed over the entire beam's coverage area as it rolls off. In other words, Qualcomm implicitly accounts for all interference received by a satellite beam by estimating the average G/T over the entire beam including all sidelobes. As

detailed in the Petition, one can divide the CONUS into smaller bins and then compute the interference received by a satellite beam by integrating over the interference terms received in each bin using the G/T value of the beam in that bin. This piecewise integration was carried out in the Petition by using the average of the G/T over the entire beam.

(3) The interference analysis indicated that 600 uplink beams, i.e., 150 ground stations each with 4 uplink beams, would raise the noise temperature of a typical FSS receiver by the calculated amount. In the presentation of November 30, 2011, you stated that 150 ground stations was a preliminary estimate and the final number of ground stations would depend on the final network design and could be as high as 250. At your assumed rate of four uplink beams per ground station, what would the effect of a hard limit of uplink beams be on the Qualcomm system, for example, 600 or 1000 uplink beams?

Response:

According to Qualcomm's design, the hard limit on the number of beams would be 1000 beams. However, as discussed in the response to Question 1 above, as the number of sites is increased over time, the transmit EIRP from the GSs and the aircraft would be decreased by the same amount so that the total EIRP from all sites/aircraft will be equivalent to that for the 600-beam example described in detail in Appendix A of the Petition.

(4) If the final network consisted of 250 ground stations, how would Qualcomm limit the interference received by the FSS to the values calculated in your proposal?

Response:

As described above, as new cells are added in certain areas, the EIRP of GSs in that area will be reduced in accordance with the new coverage area of the cell so that the total EIRP into the geo-arc remains the same and does not change the baseline interference calculation in the Petition.

(5) Your analysis assumed a front-to-back ratio for Qualcomm's phased array ground station antennas of 37 dB (see Table A.8). Does this include grating lobes and other effects or is this an average?

Response:

In the Petition, Qualcomm assumed that each GS antenna had a maximum of 0 dBi backlobe toward any GSO satellite. The current Qualcomm GS antenna specification sets the peak gain (including grating effects) in the "backlobe region" to be less than 0 dBi within ±90 degrees in azimuth and with elevation angles between 100 and 170 degrees, *i.e.*, toward the geo-arc. If the backlobe peak antenna gain is specified to be less than 0 dBi, then the gain averaged over all the beams toward the geo-arc will be considerably less than 0 dBi. Thus, using the peak backlobe value of 0 dBi in interference calculations greatly overestimates the interference impact.

Since the standard deviation of the average EIRP over all n beams is reduced by $\sqrt{n}$, then with 600 to 1000 beams over the CONUS that dynamically change their boresight, there will be significant averaging of the effect of the backlobe antenna gain variation.

(6) What protection exists to prevent a ground station antenna from generating beams pointing in directions other than toward the northeast to northwest?

Response:

To provide a full response to this technical question, Qualcomm responds to these 3 concerns:

(i) What is done to detect gross mechanical misalignment after initial installation?

(ii) How does the antenna structure prevent significant backlobe radiation towards the geo-arc?

(iii) Will the interference into the geo-arc increase if the beam forming coefficients change with time?

Response to (i) - The GS equipment would use a mechanical device to maintain physical alignment, and gross misalignment would be detected via mechanical means. The electrical boresight of the antenna can be calibrated to a rigid surface on the antenna frame, to which electrical spirit bubble levels or gyros can be attached. Movement in excess of an allowable tolerance would trigger an alarm and, if necessary, shut down operation.

Response to (ii) - The antenna structure contains unidirectional antenna elements that point northward and are backed by a large ground plane. The element patterns will roll off significantly beyond the plane of the radiating aperture. Since the array pattern is determined by the array factor pattern multiplied by the aforementioned element pattern, it is not possible to radiate a beam of significant gain in the backward looking hemisphere.

The antenna system also will be factory calibrated, and the complete GS will be tested and calibrated upon installation in the field.

Response to (iii) - The system operator would implement periodic real-time calibration procedures to ensure the beam pointing coefficients for a particular beam are within acceptable tolerances. Since the backlobe radiated energy must be below a certain level, the correct formation of the forward-looking beams (based on validation of correct beam forming coefficients) will ensure that the backlobe pattern is acceptable.

(7) Is your interference analysis based on peak or average power? If it is based on average power, please inform us of your expected peak-to-average power ratio.

Response:

The Next Gen AG system air interface uses OFDM modulation. Since the bandwidth of the GS signal is at least 20 MHz, the resulting OFDM signal will have a Gaussian envelope and behave statistically as broadband Gaussian noise that appears as additional thermal noise to the receiver. The received OFDM signal at the receiver adds to the thermal noise because its statistical properties are indistinguishable from thermal noise. In other words, the only parameter that determines the impact to the performance of the satellite receiver is the variance of the Gaussian process that models the OFDM signal, which is the average power of the OFDM signal just as the variance of the Gaussian process that models the thermal noise is used for analyzing performance of the receiver.. Therefore, in the interference calculations, only the average power of the wideband OFDM signal needs to be considered.

(8) If your system were suspected of providing interference to an FSS receiver, how would you resolve the questions of identifying/eliminating the source of interference to the FSS receiver from an aircraft or ground station transmitter?

Response:

Qualcomm first describes the methodology that could be used to test the system during the deployment and testing phase to ensure interference limits are met, and also the methodology that could be used during network operation to maintain ongoing system compliance. Qualcomm also describes how one would determine whether the Next Gen AG system is the source of interference in response to concerns raised by a FSS service provider.

The Next Gen AG air interface will include an all pilot (*i.e*., known data sequence) data packet that will be transmitted by the GSs during the initial system testing and deployment and also during normal operation to allow Signal to Noise plus Interference ("SINR") measurements on satellite transponders. The signal received at a gateway will be processed by test equipment to despread the known sequence and measure SINR. Although the GS received signal at the transponder is well below the noise floor, the SINR after despreading the GS known data sequence will be large enough to allow measurement of the received GS signal power if the transponder does not have other satellite signals in it (*i.e*., it is idle) or all other signals are small. The measured SINR will be used to validate that the received signal at the transponder is below the designed level. This measurement procedure will be used during the initial system deployment and testing to verify that all GSs are operating as designed before turning on the entire system. The sum of the measured signals from all GSs operating in this manner must add to less than the allowable Rise over Thermal ("RoT") threshold level.

During the deployment phase, the operator would test GSs one at a time as described above to ensure that all GSs function as expected and that sum of signal powers from all GSs is below the allowed level before turning the network on. The testing will be carried out by forming beams as in normal operation. The testing will be carried out at gateway facilities on rented transponders. Therefore, before turning on the Next Gen AG system, the interference measurements would be made directly on satellite transponders. The measured results on one transponder may be extrapolated to other transponders by comparing the G/T and other parameters of the different satellites.

During the operation of the Next Gen AG network, each GS will transmit the known data sequence at specified times to allow the measurement set up at the operator's premises to perform SINR measurements on each GS to ensure that all GSs are functioning as expected. The SINR measurement on a satellite transponder will continue during the normal operation to allow real time monitoring of the system. This test methodology provides a picture of received signals from all GSs at the transponder as well as the sum of the signal powers and will demonstrate proper operation on an on-going basis. The same methodology described above may be used to measure received signal levels from specific aircraft.

If there is a request from an FSS service provider to show that the Next Gen AG system is not the source of interference to its service, the above procedure may be used to measure the Next Gen AG system signal levels at the transponder. The operator can use the testing methodology described above to measure GS (and, if needed, aircraft) received signal power levels on the specific transponder or to make the measurements on a different transponder and extrapolate the result to the level that another transponder would see as a worst case. Because the known pilot sequences have a different signature for different GSs and aircraft, any signal anomalies seen

may be tracked to a specific GS or aircraft so that corrective action can be taken, if necessary. The rented transponder that does not carry any satellite signal can be used by the Next Gen AG system operator to measure the signal characteristics of GSs and aircraft on a specific frequency channel and identify any anomalies. These measurements also may be made on another satellite and transponder if requested.

The methodology detailed above provides direct measurement of Next Gen AG signals on transponders and is repeatable. However, if desired, it is possible to design other test methods such as a test data call with alternating transmit and silence periods to allow direct average power measurements during the two periods to estimate total power with and without an active Next Gen AG signal. In addition, this test data call may be sent on a narrower bandwidth to allow more accurate direct power estimation.