June 15, 2016

Ex Parte

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

RE: *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, et al., GN Docket No. 14–177, RM–11664*

Dear Ms. Dortch:

This submission to the record describes an analysis and simulation performed by Ericsson on the impact of intra band uplink interference from 5G User Equipment ("UE") in the 28 GHz band towards Fixed Satellite Service ("FSS") systems. The satellite industry has expressed concern and proposed a regulatory solution for potential aggregate interference that Upper Microwave Flexible Use Service ("UMFUS") UE transmitters may have to the performance of satellite communication.

Based on parameters provided by the Satellite Operators[1] and other satellite proponents' submissions to date, Ericsson's analysis and simulation show that the interference towards satellite systems from UMFUS UEs in the spot beam is expected to be insignificant in comparison with the interference thresholds at the satellite. The analysis concludes that within the vicinity of the earth station the number of UEs representing a threshold of 6% interference level at the satellite[2] far exceeds any number that can reasonably be expected to be deployed.

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[1] *See* Letter from EchoStar, Inmarsat, Intelsat, O3b Limited, OneWeb, SES Americom, Inc., and ViaSat Inc. (collectively, the "Satellite Operators") to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 14-177 *et al*. (filed May 12, 2015) ("*Satellite Operators Letter*").

[2] This figure represents a -12.2 dB I/N interference threshold proposed by the Satellite Industry Association (SIA). We believe this threshold value is an overly stringent requirement and propose that any further analysis be

Mark Racek
Sr. Director, Spectrum Policy
Ericsson
1776 I St., NW
Suite 240 Tel: +1 202 824-0110
Washington, DC 20006 Email: mark.racek@ericsson.com

Furthermore it is not appropriate for the Commission to adopt a proposed aggregate emissions limit radiated skyward of ≤ 16.5 dBm / MHz EIRP / 1000 km^2 in the 28 GHz band as recommended by the Satellite Operators.[3] The entire spot beam area is where the aggregate interference limit applies and having a localized concentration of interference, such as from an urban area, would not increase the overall interference. UFMUS systems will not be uniformly deployed over the area of a satellite's spot beam on the earth's surface. Any limits imposed on a subset of the spot beam area regarding power radiated skyward, e.g. the aggregate radiated emissions of 16.5 dBm/MHz/1000 km^2, would unfairly penalize UMFUS infrastructure deployment and user capacity in population centers, where most of the traffic is expected to originate. Therefore, such a regulation is not appropriate and should not be adopted. It is not necessary to restrict the design of UMFUS equipment including mandates that may dictate equipment deployment configurations including downtilt, power control, etc. These techniques have been used in industry simulations, including the present analysis, to demonstrate specific concepts of 5G deployments and are not meant for codification by the Commission into rules.

Wireless System Aspects

With the introduction of the UMFUS, wireless systems are expected to be deployed in proximity to FSS earth stations in the 28 GHz band. We have considered that UEs in the band will be served by 3-sector UMFUS base station sites. Typically, UMFUS base stations will be spread over a large area corresponding to the area of the satellite spot beam on the surface of the earth. Such base station deployments will not be uniform; population density concentrations will increase the numbers of base stations. High base station densities will result in radio planning that dimensions lower power at the base station to account for lower inter-site distances, and subsequently it is expected that UEs transmitting from densely populated areas will also be at a closer distance to the base station. Therefore this means that deployments will typically be non-uniform within large areas on the earth's surface.

This study does not model non-uniform effects corresponding to deployment, and instead accounts for the density variation in the deployment by lowering the activity factor from UEs to an average level, which is in accordance with modelling practices for cellular systems.

As with LTE, Transmission Time Intervals ("TTI") are used to coordinate multiplexing and access control. In the 28 GHz band, Time Division Duplexing ("TDD") will be employed and therefore downlink and uplink transmissions will occur in independent non-overlapping time intervals per base station. While the division between uplink and downlink allocations is likely to be dynamic, the modeling here assumes

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performed using a threshold of 25% interference, or an I/N ratio of -6 dB. *See* letter from AT&T Services Inc.; Ericsson; Nokia; Samsung Electronics America, T-Mobile USA, Inc. and Verizon to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 14-177 *et al*. (filed June 1, 2015) ("*Joint Filers Letter*") (The Joint Filers noted that the Satellite Operators have used an unrealistic -12.2 dB in lieu of providing data on their actual receiver performance and related characteristics necessary to model RF impacts on their systems).

[3] *See Satellite Operators' Letter* at attachment pg 5.

coordination so as to provide an estimate of the limits to which deployment density may be taken for the uplink. In this study each UE is allocated 100 MHz of bandwidth in one TTI of 200 μs during its scheduled period. While the number of UEs served by a base station may number in the thousands, that number is not pertinent to the interference calculation, as interference is only generated by transmitting or "active" users (in each TTI and sector).

In practice, peak power is rarely employed in UEs. Power control is used to ensure as much energy consumption as necessary to remain below the channel capacity. The system is engineered so that a large number of served users are within the power control range, and the maximum EIRP is employed only when the angular spread of the channel to the base station is very low, and the UE is at the cell edge. In this respect, our analysis is likely to be conservative and overprotective of satellite operation.

At 28 GHz, UE transmissions will be directional. Beamforming is an essential aspect of the UMFUS system, and phased arrays serve to improve the link gain towards the desired receiver, while simultaneously having the benefit of lowering the interference level towards other victims in the environment. Needless to say, satellite systems are the beneficiaries because every radio in the UMFUS will act to minimize the amount of energy radiated in unwanted directions, skyward being one typical example.

Satellite System Aspects

The earth-to-satellite link (*i.e.*, uplink) is modeled by an earth station transmitting towards the satellite with a directional transmit ("Tx") antenna , and a satellite receiving the signal with a directional (typically parabolic) receiver ("Rx") antenna.

This study analyzes the interference impact towards the satellite system for the UEs that are communicating with the UMFUS basestation and radiating in the uplink frequencies towards the base station and within the vicinity of an earth station. This analysis estimates the aggregate interference generated by UEs towards the satellite in a typically deployed and operating UMFUS network.

To estimate the interference generated by the UEs in a network, scheduling of transmission, power control of the UE, and directional antenna characteristics of the UMFUS components and the satellite receiver have been considered. Power control and beam direction are monitored and adjusted during communication for optimal performance. One UE will be scheduled at each frequency at a time per base station.

Essential data for four satellite configurations are considered in Table 1.[4]

[4] The satellite industry has proposed stringent transmission limits for UMFU systems based on parameters for future satellite systems represented as CLASS 1 and CLASS 2 in our study.

	Class 1	Class 2	Class 3	Class 4[5]
Antenna gain (dBi)	60	60	30	50
Satellite angle above horizontal (degrees)	30	14.6	5	30
Distance to satellite (km)	~37,000	~37,000	~11,000	~37,000

Table 1. Satellite Configurations

Simulation Results

The Ericsson simulation models a U.S. suburban environment. The propagation from the UE to the satellite is modelled in two stages, one to account for the effects of reflection and diffraction to get the transmitted signal above the city clutter, and the second stage to account for the free space loss along with atmospheric effects towards the satellite receiver.

The simulation models the following UMFUS deployment:

- 81 sites with three sectors = 243 base stations at a height of 6m without any antenna down tilt.[6]
- One simultaneously transmitting UE per BS at height 1.5m above ground, and the following characteristics:
    - beamforming antenna in the UE (boresight always pointing towards the destination BS),
    - UE power control
    - 3 different angles towards the satellite (5, 14.6 and 30 degrees)
    - 1000 random snapshots of UE placement.

[5] Class 4 parameters are based on of currently deployed geosynchronous orbit satellite systems, which is ~50 dBi (based on applications submitted to FCC). The parameters considered for CLASS 4 and CLASS 1 are identical in all other aspects.

[6] This is a minor impact to the UE simulation because UEs will transmit at a slightly higher power due to the misalignment with the base station receiver antenna's boresight.

Figure 1 illustrates the Cumulative Distribution Function ("CDF") of the probability of an individual UE's power level towards the base station. The use of power control results in a significantly lower median power setting than the maximum of 43 dBm.

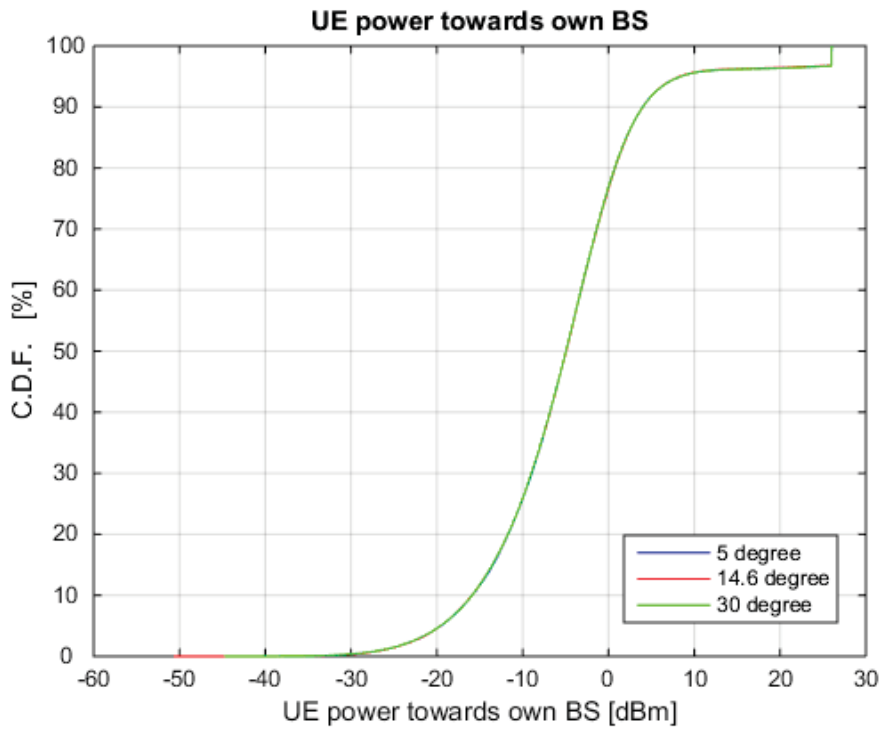

Figure 1. UE Power towards UMFUS BS

UEs are capable of dynamic beamforming with a maximum gain of 17 dBi. The simulation model assumes a symmetrical antenna beam with a single main lobe as shown in Figure 2.

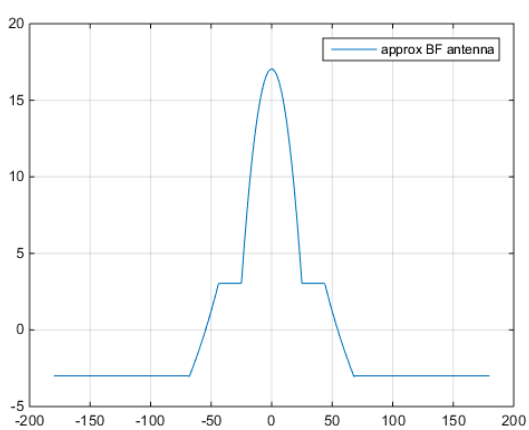

Figure 2. Antenna diagram

The radiated power in the direction for the satellite is calculated at the antenna of each UE and accumulated to calculate aggregated power. The aggregated power is then normalized by the number of UEs. Figure 3 plots the antenna discrimination results per UE antenna at each of the three satellite angles.

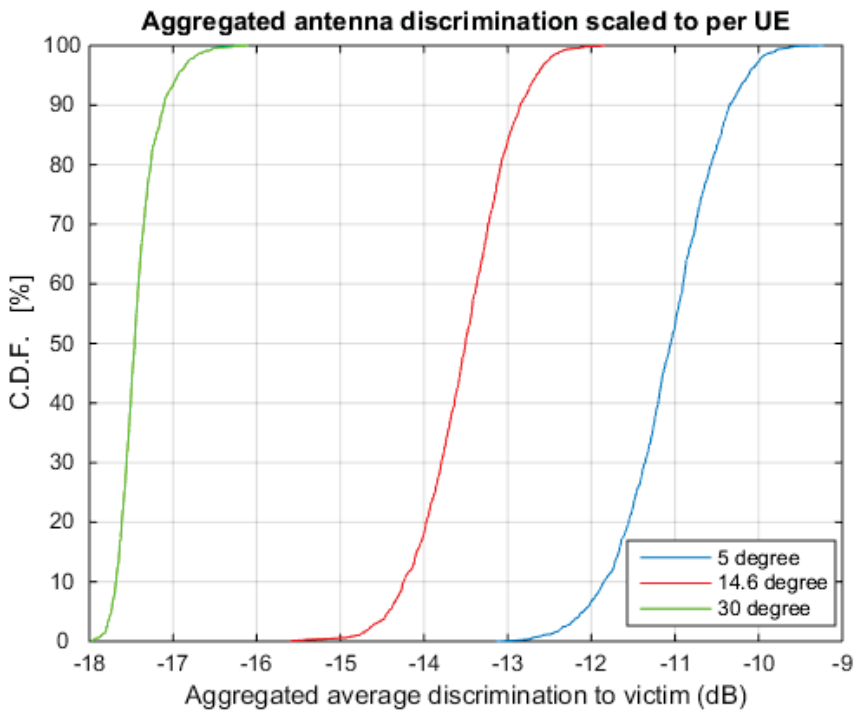

Figure 3. Distribution of the Antenna Discrimination at each of 3 satellite angles

In order to give a consolidated view of the discrimination, the above analyses were combined to create the probability distribution CDF of aggregated discrimination. Power control and beamforming are used simultaneously. Clutter around the UE will give an additional 20 dB discrimination. The aggregated average discrimination compared to the max EIRP in the beam direction are shown in Figure 4. The estimated discrimination for the 5, 14.6, and 30 degree satellite elevation is 41 dB, 45 dB, and 49 dB respectively.

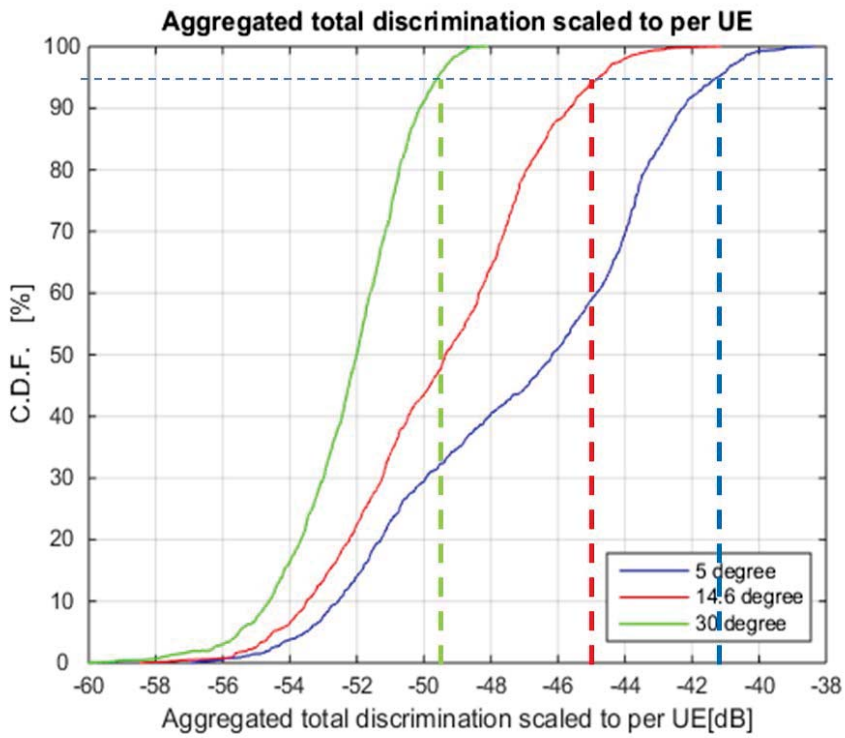

Figure 4. Aggregated Total Discrimination per UE

The direction towards the base station (and indirectly towards the satellite) as well as the power level used by the UE is highly dependent on the location of the UE in the cell. For example, when the UE is close to the base station, low power is used. The simulations take this correlation into account when estimating the aggregated discrimination.

Table 2 shows the values for discrimination at 95% of the samples.

	Class 1	Class 2	Class 3	Class 4
Satellite angle above horizontal (degrees)	30	14,6	5	30
UE max EIRP (dBm)	43	43	43	43
UE bandwidth (MHz)	100	100	100	100
Discrimination at 95% probability (dB)	49	45	41	49
Interference toward satellite with 43 dBm EIRP UE (dBm)	-6	-2	2	-6
Interference toward satellite with 43 dBm EIRP UE (dBm/Hz)	-86	-82	-78	-89

Table 2. Results with Discrimination at 95%

The interference impact at the satellite is then calculated by adding the path loss along the earth-to-space link. Table 3 shows an estimate on the number of simultaneous transmitting UEs, which represent the number of sites deployed, that may be used in the vicinity of the earth station.

	Class 1	Class 2	Class 3	Class 4
Antenna gain (dBi)	60	60	30	50
Free Space Path loss (dB)	212.8	212.8	202.2	212.8
Polarization and Atmospheric loss (dB)	4	4	4	4
Interference per UE at Satellite (dBm/Hz)	-245.8	-241.8	-257.2	-255.8
Interference threshold (dBm/Hz)	-183	-183	-183	-183
Number of active transmitting UEs Required to Exceed Threshold	~955,000	~380,000	~13,183,000	~9,550,000
Number of 3 sector Base Stations sites Required to Exceed Threshold	~318,000	~127,000	~4,394,000	~3,183,000

Table 3. Impact to Satellite using path loss calculation

Conclusion

It is expected that UMFUS systems will be deployed in the proximity of FSS earth-stations in the 28 GHz band. Ericsson has conducted an analysis that simulates the aggregate impact of intra-band uplink interference from 5G UE equipment in the 28 GHz band towards FSS systems. For currently operating satellites classified as CLASS 3 and CLASS 4, the analysis above shows that the active number of simultaneously transmitting UEs required to exceed threshold is 9.55 Million in the spot beam area, a number far greater than reasonably expected for deployment. Hence, there is little cause for concern about aggregated skyward EIRP from UMFUS. However, the Satellite Operators have submitted a proposal for aggregate emissions that is based on a subset of the spot beam area regarding power radiated skyward that does not recognize the non-uniform deployment of UMFUS. This would unfairly penalize UMFUS infrastructure deployment and user capacity in population centers, where most of the

traffic is expected to originate. Therefore, such a regulation is not appropriate and should not be adopted.

Sincerely,
/s/ Mark Racek
Mark Racek
Sr. Director, Spectrum Policy

Anders Svensson
Kumar Balachandran
Sanjay Dhawan

cc: Julius Knapp
Jon Wilkins
Michael Ha
Bahman Badipour
Rashmi Doshi
Reza Biazaran
Chris Helzer