Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Unlicensed Use of the 6 GHz Band	)	ET Docket No. 18-295
	)	
Expanding Flexible Use of the Mid-Band Spectrum Between 3.7 and 24 GHz	))	GN Docket No. 17-183

REPLY COMMENTS OF RKF ENGINEERING SOLUTIONS, LLC

RKF Engineering Solutions, LLC (RKF) is respected worldwide as an industry expert in spectrum analysis and management, regulatory processes, and communications system engineering. RKF has performed countless sharing studies evaluating interference paths between incumbent and new systems. Founded in 2001, RKF provides technical studies and analyses to both government and commercial clients across regulatory environments with a special focus on telecommunications systems involving satellite communications (GEO, MEO, and LEO constellations), and high altitude platforms (HAP)/drones and terrestrial communications systems, including cellular and fixed microwave (FS).

RKF has performed these studies and analyses across the frequency spectrum from L band through E band (70 GHz) and has used a wide array of simulations and propagation models as well as measurement campaigns to determine the viability of sharing between systems within these bands. In addition to performing spectrum sharing analyses for unlicensed device use in the 6 GHz band, RKF is currently simulating LTE protocols and modeling detailed propagation effects for the United States' Defense Spectrum Office (DSO) to coordinate spectrum sharing between DOD and LTE services. RKF has performed similar sharing studies for multiple LEO satellite constellations, providing technical analyses for sharing studies between cellular and other FS systems, and supporting national, regional and international regulatory meetings. With its vast experience and knowledge, RKF has the regulatory and system modeling expertise necessary to analyze sharing between RLAN and FS in the 6 GHz band.

To analyze the frequency sharing for RLANs in the 6 GHz band, RKF modeled a number of variables including RLAN EIRP, bandwidth, FS locations, propagation environments, antenna heights, and numerous others. With the number of varying parameters, RKF determined that a Monte Carlo simulation approach would provide the most realistic spectrum sharing assessment by incorporating the statistical variation of all modeled parameters to account for the *full probability distribution* of all the variables involved. To set the baseline predicted interference environment, the RKF study[1] looked at the interference risk from RLAN devices to licensed incumbents in the 6 GHz band using the U-NII-3 rules *without* additional mitigations such as those the FCC has now proposed as part of an automated frequency coordination (AFC) system. This allowed the simulation to identify low-probability worst-case events in the absence of any mitigation process and to quantify their probabilities of occurrence.

Although a Monte Carlo analysis employs probabilities, it is fundamentally different from the "average of averages" approach that some have described.[2] Monte Carlo simulation methodology is generally applicable in cases where a system has statistically varying inputs, and

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[1] *Frequency Sharing for Radio Local Area Networks in the 6 GHz Band* (Jan. 2018), *attached to* Letter from Paul Margie, Counsel to Apple Inc., Broadcom Inc., Facebook, Inc., Hewlett Packard Enterprise, and Microsoft Corporation, to Marlene Dortch, Secretary, FCC, in GN Docket No. 17-183 (filed Jan. 26, 2018) (RKF Study).

[2] *See e.g.*, Comments of FWCC at 11-14, ET Docket 18-295, GN Docket No. 17-183 (filed Feb. 15, 2019) ("FWCC Comments"); Comments of the National Association of Broadcasters at 5, ET Docket 18-295, GN Docket No. 17-183 (filed Feb. 15, 2019) ("NAB Comments").

it is computationally infeasible to analytically compute the statistical nature of the output. Monte Carlo analysis involves evaluation of the full distributions of potential values (of the statistically varying inputs), and their associated probabilities, for relevant study parameters.

The effectiveness of the Monte Carlo method is dependent on the accuracy of the statistical model of each input, and a long enough running time to be statistically significant. The notion of statistical significance encompasses hitting very low probability events, or worst cases, in each of the underlying input distributions. Indeed, the fundamental purpose of this technique is to *avoid* the pitfalls produced by an analysis focused on the average case.

In the case of the 6 GHz simulation to determine the impact on FS I/N, this involved a careful study of numerous inputs to the simulation. Namely, the precise number and location of each active RLAN device, the transmit EIRP of each active RLAN device, path loss, and building penetration loss were the most significant inputs, each of which was selected using statistical models derived from empirical data.

None of these values were simply averaged. Rather, they were independently developed based on industry research (e.g., enterprise and consumer AP vendor E-plane antenna patterns), government data sets (e.g., U.S. Census Bureau population distributions) and ITU models (e.g., P.2109 building entry loss) to study the probability of any one of these values occurring in combination with the various possible values of the other parameters.

To capture the full range of potential scenarios, we conducted ten independent runs over the 91,187 FS receivers in CONUS (per ULS database), each with an independently generated geographic distribution of RLANs. RLAN locations are spatially distributed such that the probability density at a specific location is proportional to the population density at that location for Urban, Suburban, and Rural environments. There were, on average, 551 RLANs that contributed to the I/N at each FS. This resulted in 502 x 10^6 different morphologies (=91,187 FS x 551 RLANs x 10 iterations), which is sufficiently large for the results to be statistically significant to estimate very low probabilities (even lower than 10^-6).

The outputs from each simulation are the I/N present at each FS receiver. Calculated I/N values are recorded and used to create a histogram of I/N values at each FS receiver. These histograms are then used to estimate the Cumulative Distribution Function of the statistically varying I/N values produced by the simulations. *Note that I/N values are not averaged over many runs, but rather many runs are used to estimate the underlying interference statistics*. The full interference distribution is considered.

We agree that it is important to assess the probability and magnitude of infrequent, worst-case events. But the Commission cannot make fully informed decisions based only on hypothetical worst-case examples. A reasonable approach would combine these worst-case examples with real data about the probability of such events, and their severity if they were to occur. Providing such data was the goal of our study. Therefore, the results of this study can be used to predict the outcome of permitting RLAN devices in 6 GHz under U-NII-3 rules, without additional mitigations such as AFC.

Some parties have taken issue with specific aspects of this analysis. The 6 GHz RLAN Group has responded to many of these, but we also would like to highlight the following additional responses.

Reply to Comments on Propagation Model Assumptions

In response to concerns raised by FWCC's comments,[3] the RKF study used the WINNER II propagation model[4] for RLANs in Urban and Suburban environments up to 1 km away from the FS receiver. The WINNER II model is based on a large set of measurements that capture the variability of the different morphologies, and in doing so, takes into account location and structure variability for Urban and Suburban areas. The result is a model that has a median value (which is median clutter) and a standard variation (due to statistically varying shadowing) for both LOS and NLOS paths that are captured in our analysis. As such, our analysis does capture LOS paths with little or no clutter.

In response to NAB's comments on the RKF study ignoring worst-case scenarios such as "building penetration losses for devices operating near windows,"[5] ITU-R Rec. P.2109 is a statistical model that includes variability in building penetration loss through thermally efficient and thermally inefficient buildings, including the likelihood of going through windows. We used this model to produce building penetration loss values for each RLAN-to-FS path in each simulation. As such, our study included "worst-case" scenarios, such as thermally inefficient buildings and devices transmitting directly through windows.

In response to NAB's comments on the clutter loss being unknown and highly variable,[6] ITU-R Rec. P.452, which we used to estimate clutter loss in rural areas, is designed for

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[3] FWCC Comments at 4, 23-34.

[4] Pekka Kyösti et al., *WINNER II Channel Models*, IST-4-027756, D1.1.2 v1.2 (last updated Feb. 4, 2008), https://www.cept.org/files/8339/winner2%20-%20final%20report.pdf.

[5] NAB Comments at 5.

[6] *Id.* at 7.

coordination of individual paths and provides conservative results if used for statistical analysis. We agree that in analyzing a particular path, one can't rely on a specific clutter loss. However, the RKF study was designed to take into account the full distribution of propagation effects and a wide variety of morphologies to represent the full statistical distributions of the interference.

The RKF analysis represented the scenarios described in NAB's comments,[7] where both known locations give good link closure and locations where the ENG crew moves the truck to close the link. To ensure we calculated a valid number of statistically significant BAS cases with different morphologies and environments, we did not include locations that required the crew to move the truck to close the link, because the lack of an operable link in the absence of any potential RLAN interference renders the question of RLAN interference moot in these cases. In our report, we noted that the ENG crews already (and frequently) take corrective action when there is a problem with link connectivity. This was based on guidance from NSMA for FS link coordination, and we note that NAB confirmed that this exact procedure is followed by ENG truck operators in its comments. The resulting simulation statistics show that the interference level that might occur once a good transmit location is found is small compared to what the ENG crews already mitigate. Therefore, the addition of RLAN interference has a negligible impact on actual operations and practices.

<u>Reply to Comment on FSS Protection Criteria</u>

Comments jointly filed by SES and Intelsat suggest that protection criteria for FSS should be based on aggregate power referenced to a beam or a set of beams rather than an I/N threshold.[8] However, provided that satellite receiver gain and the thermal noise could be

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[7] *Id.* at 5-7.

[8] Comments of Intelsat License LLC and SES Americom, Inc. at 10-11, ET Docket No. 18-295, GN Docket No. 17-183 (filed Feb. 15, 2019).

determined, this would be equivalent to an I/N protection threshold over the relevant coverage areas.

The comments also include the claim that certain satellites exhibit G/T as high as 12.2 dB. However, in reviewing satellite application filings in the FCC's IBFS database, we have not seen a satellite with G/Ts this high covering all of CONUS. From our analysis of the filings, a G/T of about 2 dB (including antenna temperature) is the maximum for satellites with CONUS coverage. We analyzed a full-CONUS beam, rather than spot beams, to simulate the worst-case scenario because that would encompass all the 958,062,017 interfering RLANs throughout the U.S. Spot beams have higher G/T in a smaller coverage area and receive a small fraction of the interference from RLANs operating throughout CONUS.

It could theoretically be possible to design a receive antenna to provide a CONUS beam with a gain as high as about 32 dBi. But this is merely hypothetical and would not significantly change our findings even if it existed. Using the SES/Intelsat proposed satellite receiver thermal noise level of 257 K, a theoretical G/T of 7.7 dB (based on thermal noise only) is possible, 5.7 dB higher than the G/T used in our report. This would theoretically increase the maximum simulated I/N from -28.6 dB to -22.9 dB, still much lower than the -13.5 dB I/N threshold proposed by Intelsat. Therefore, there would still be significant margin to account for RLAN growth in the band. In addition, other factors need to be considered in calculating the aggregate power at the satellite receiver, include building penetration loss for indoor RLANs, clutter loss, and frequency dependent rejection in calculating the power that gets into the satellite channel. Therefore, even with the most conservative estimates of G/T, our analysis shows significant margin.

Without opining on the appropriateness of the -13.5 dB I/N requirement proposed by Intelsat/SES, more than 9 dB of margin exists relative to that threshold.

Respectfully submitted,

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18 March 2019