5G/Weather Satellite 24 GHz Spectrum Disagreement: Anatomy of a Spectrum Policy Issue

Michael J. Marcus

This column may be the only place in IEEE publications where spectrum policy issues are regularly discussed. More generalized technical publications and the popular press discuss spectrum policy only on rare occasions. However, in May 2019 there was a flurry of articles in the popular press, some general technical publications, and even on social media about an issue that previously was known only to specialists in the field. While it is unclear what exactly triggered this burst of publishing activity, the issue it dealt with is a good example of spectrum policy issues that can have a large impact and the need for careful technical analysis in addressing such issues. (To find these articles, input into your favorite Internet search engine the terms: 5G, weather, FCC, 24 GHz.)

The issue that stimulated all this activity is the creation of one of several new cellular bands for fifth generation (5G). The band under consideration near 24 GHz is close to a band that is used by passive satellite sensors to detect water vapor, and there are concerns that out-of-band-emissions from 5G base stations and/or mobile units might in aggregation degrade the performance of the passive satellite sensor and thus hinder weather forecasting. UK's *Nature* reported:

> "The US government has begun auctioning off blocks of wireless radio frequencies to be used for ... 5G ...(M)eteorologists are worried that 5G mobile-phone transmissions could hamper their data collection. Earth-observing satellites flying over areas of the US with 5G wireless coverage won't be able to detect water vapor in the atmosphere accurately...and without (this information) weather forecasts worldwide are likely to suffer."[1]

Nontechnical publications were sometimes much more alarmist and quoted a government official responsible for weather forecasting that the expected interference "would result in the reduction of hurricane track forecast lead time by roughly two to three days".[2] Social media discussions seem polarized on either defending the weather satellites or saying that the problem wasn't real and was delaying 5G.

In a previous column here[3] we wrote about the International Telecommunication Union's (ITU's) World Radiocommunication Conference 2019 (WRC-19) that will convene in Sharm el-Sheikh, Egypt, from 28 October to 22 November 2019. These conferences are held every three to four years. That column discussed the agenda items that will be finalized at the conference. One of those items discussed has recently become a very public controversy in the United States and as such is an example of protracted controversies that can arise in spectrum policy deliberations. The issue involves Agenda Item (AI) 1.13 dealing with identifying frequency bands for the future development of International Mobile Telecommunications (IMT), often called 5G in this context. In particular, the band involved is the new 24.25–27.5 GHz 5G band. The specific controversy is what measures are necessary to ensure that base station and user equipment transmitters in this band do not cause interference to passive weather satellites known in ITU jargon as Earth Exploration Satellite (Passive) Service/EESS in 23.6–24.0 GHz. The nature of the EESS systems in this band are described in ITU-R Recommendation RS.1861.[4]

Under the terms of longstanding ITU Radio Regulation(RR) 5.340, "all emissions are prohibited" in 23.6–24 GHz, which has both an international and U.S. primary allocation for EESS and two other passive services. RR5.340 is a treaty obligation of ITU member nations; however, we know from Fourier theory that for practical transmitters a zero emission limit into a nearby band is not physically possible. FCC recognized the possible conflict between the EESS band and the nearby 5G band in decisions in both 2017 and 2018. It noted both times that there were ongoing ITU-R studies addressing the technical criteria needed to avoid interservice interference and that the issue would be resolved for the ITU at WRC-19, where a new allocation for 5G above 24 GHz is planned:

> "The Commission recognizes the need to protect these passive satellite operations that provide important data necessary for weather predictions and warnings. Once the international studies have been completed, interested parties may propose revisions to the Commission's rules as necessary for protection of weather satellites operating in the 23.6–24.0 GHz band."[5]

> "We encourage (U.S. 5G) operators in the 24 GHz band to monitor these studies and to plan their systems, to the extent possible, to take into account the potential for additional future protection of passive sensors in the 23.6-24.0 GHz band."[6]

Thus, U.S. 5G interests have been warned that quantitative ITU emission limits into the passive band may be adopted at WRC-19, and they may be required to meet those limits in the future.

The WRC-19 Conference Preparatory Meeting (CPM) revealed how large the national disagreements are on this issue. CPM results[7] document the different views of various nations and regions on the protection issue. These were given in terms of emission limits into 23.6–24 GHz for either base station (downlinks) or mobile equipment (uplinks). The units used for these at CPM were denominated in power spectral density units dBW/200 MHz. The United States advocated a limit of –20 for both uplinks and downlinks, while the Conference of European Postal & Telecommunications (CEPT), representing the spectrum regulators in Europe, advocated –42 for downlinks and –38 for uplinks.

What are the causes of this major disagreement on new spectrum use? All sides want to eliminate "harmful interference" to allocated primary services. Previously we have discussed the vague definition of harmful interference at both the national and international levels.[8] The controversy here involves the question of out-of-band-interference from numerous base stations and mobile units using multiple-input multiple-output (MIMO) anten-

[1] A. Witze, "5G Data Networks Threaten Forecasts: Wireless Technology Could Interfere with Earth Observations," *Nature*, vol. 569, no. 17, May 2, 2019.

[2] https://www.bloomberg.com/news/articles/2019-06-04/march-to-5g-could-trample-hurricane-tracking-scientists-warn

[3] M. Marcus, "WRC-19 Issues: A Survey," *IEEE Wireless Commun.*, vol. 24 , no. 1, Feb. 2017, pp. 2–3.

[4] ITU-R Rec. RS.1861, Sec. 6.6, "Typical Technical and Operational Characteristics of Earth Exploration Satellite Service (Passive) Systems Using Allocations between 1.4 and 275 GHz," 2010.

[5] FCC, 2nd Report & Order, Docket 14-177, Nov. 16, 2017, para. 22;https://docs.fcc.gov/public/attachments/FCC-17-152A1_Rcd.pdf

[6] FCC, 3rd Report & Order, Docket 14-177,June 7, 2018, at para.15; https://docs.fcc.gov/public/attachments/FCC-18-73A1.pdf

[7] ITU, "Report of the CPM to WRC-19," Mar. 2019; https://www.itu.int/md/R15-CPM19.02-R-0001/en

[8] M. Marcus, "Harmful Interference and Its Role in Spectrum Policy", *Proc. IEEE*, vol. 102 , no. 3, Mar. 2014, pp. 265–69.

nas within the footprint of a passive satellite receiver's antenna. Analyses of such scenarios requires a Monte Carlo simulation with a large number of assumptions. Some of the assumptions; for example, the out-of-band emission radiation pattern above the horizon elevation angles for MIMO antennas is not well documented nor is it documented how much it could be reasonably reduced in alternative designs if necessary to ameliorate interference with weather satellites. Thus, in making these analyses of necessity, one must make many assumptions and use simulation techniques that do not have broad acceptance. Such analyses, when done by proponents of one point of view, can be unintentionally biased as they may make too many worst case and best case assumptions where factual information is now actually available. FCC Chairman Pai has observed in this case:

> "The studies submitted by weather satellite interests have proposed the most extreme protections while other studies justify far less necessary interference protections."[9]

Even review of an analysis by a balanced set of experts can have trouble sorting out all the assumptions used in these complex studies and checking them for validity. While independent studies by directly affected parties are very useful in simpler interference scenarios, in scenarios of this complexity with new and emerging technology more explicit cooperation between the two sides of the disagreement throughout the whole analysis along with sensitivity studies to some of the assumptions may be necessary to timely reaching of consensus on such issues.

This controversy highlights that the radio spectrum is shared by a wide variety of uses which vary greatly in their technical and operational details. In the early days of spectrum policy, disparate uses were kept in widely separated bands. This is generally not possible today due to the ever growing demand for spectrum access.

While the subject of this magazine is "wireless communications," and it has a strong focus on IMT-like technology, the radio spectrum has to be shared with a wide variety of other uses. While generally one type of spectrum use has to share a specific frequency band with either no other types or a small number of other types, the real limitations of transmitters, receivers, and antennas lead to concerns of possible interference between nearby bands, as is alleged in this situation. It is vital to maintain an effective dialogue between varying classes of spectrum users so that these problems can be identified as early as possible and addressed cooperatively and fairly in a timely fashion.

Biography

Michael J. Marcus (mjmarcus@marcus-spectrum.com) (S '66, M '72, SM '01, F '04) is Director of Marcus Spectrum Solutions, Cabin John, Maryland and adjunct professor at Virginia Tech's Bradley Department of Electrical and Computer Engineering. He retired from the Federal Communications Commission in 2004 after nearly 25 years in senior spectrum policy positions. While at FCC, he proposed and directed the policy developments that resulted in the bands used by Wi-Fi, Bluetooth, and licensed and unlicensed millimeter wave systems above 59 GHz. He was an exchange visitor from FCC to the Japanese spectrum regulator (now MIC) and has been a consultant to the European Commission and the Singapore regulator (now IMDA). During 2012-13 he was chair of the IEEE-USA Committee on Communication Policy and is now its vice chair for spectrum policy. In 2013, he was awarded the IEEE ComSoc Award for Public Service in the Field of Telecommunications "for pioneering spectrum policy initiatives that created modern unlicensed spectrum bands for applications that have changed our world." He received S.B. and Sc.D. degrees in electrical engineering from MIT.

[9] Letter from A. Pai to M. Cantwell, June 11, 2019; https://docs.fcc.gov/public/attachments/DOC-358166A1.pdf

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