

Lecture 18- Pre-lecture reading

Push for Newer Spectrum and Unintended Consequences

5G systems currently under development aim to provide a significantly enhanced mobile user experience compared to 4G systems with Gbps wireless bit-rates along with low latency and improved reliability. New radio access technologies such as massive MIMO, multiple radios, millimeter wave, beam steering cloud radio access networks (CRAN) have been proposed to achieve large gains in physical layer radio performance. Supporting Internet-of-Things (IoT) applications is another 5G design goal, introducing requirements such as high device density, low complexity and energy efficiency.

In addition to the emphasis on the development of new radio access technologies needed to achieve higher wireless bit-rates, an important and necessary aspect of the 5G and Beyond 5G (B5G) developments has been the opening up and utilizing of newer spectrum that had not been previously allocated for commercial wireless applications. This newer spectrum has included bands in both sub-6 GHz and mmWave bands (above 24 GHz). Such new spectrum opportunities for 5G often come with concerns, speculation and even controversy, when it relates to impacting collocated or adjacent portions of spectrum that are utilized for other services. This has led to the emergence of a new area of research (and concern) referred to as “Passive Spectrum Coexistence” where the goal is to design wireless communication systems such that the “leakage/interference” from these systems do not adversely impact other (possibly) non-communicating services, systems and sensors. These systems are referred to as “passive” in that they do not have the ability to combat any unintended interference or leakage from the wireless communication devices.

Impact on Weather Forecasting

An important recent example of such concern and speculation has been the issue of the impact of 5G services and radio transmissions on weather forecasting, along with possible mitigation strategies. Specifically, the 5G band allocated in the 26 GHz spectrum referred to as 3GPP band n258 (see Figure 1), has generated a lot of anxiety and concern in the meteorological data forecasting community including the National Oceanic and Atmospheric Administration (NOAA).

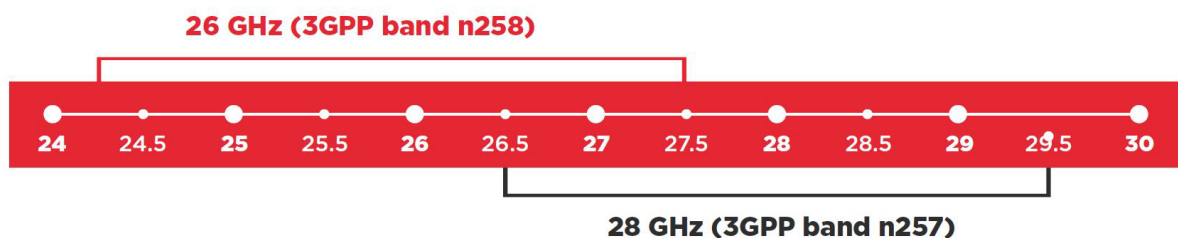


Figure 1: 5G Spectrum Allocations in 26 GHz and 28 GHz

From a communications technology perspective, experts in the 5G industry and the FCC have been debating this point in the buildup to 5G. In fact, recent versions of the 3GPP's 5G specification specifically have a "carveout" to protect satellite weather services, by reducing the emission levels of neighboring 5G signals between 24.25 and 27.5 GHz. But NOAA is arguing the current emission requirements aren't enough — it'll lose that critical data unless they're clamped down even further. Unlike traditional spectrum coexistence issues, the issue of 5G transmissions in the n258 band stem from the 5G transmissions impacting the observations of passive sensors (e.g. Advanced Microwave Sounding Unit, AMSU-A or Advanced Technology Microwave Sounder, ATMS) on weather satellites used to detect the amount of water in the atmosphere, which in turn affects weather forecasting and predictions. The 5G transmissions will involve many frequencies, but the key one under discussion is 23.8 GHz. Water vapor in the atmosphere naturally produces a weak signal at this frequency, which satellites use to measure humidity, which is then fed into weather forecasts. But if a 5G station is transmitting a signal near the 23.8 GHz frequency (such as the n258 band), a passive sensor on a weather satellite measuring water vapor might be affected, resulting in erroneous data which in turn could degrade weather predictions that rely on accurate measurements of water vapor content in the atmosphere (see Figure 2 below). The debate about what is considered as acceptable leakage from 5G transmissions ranges from a low of -55 dBW to a high of -20 dBW.

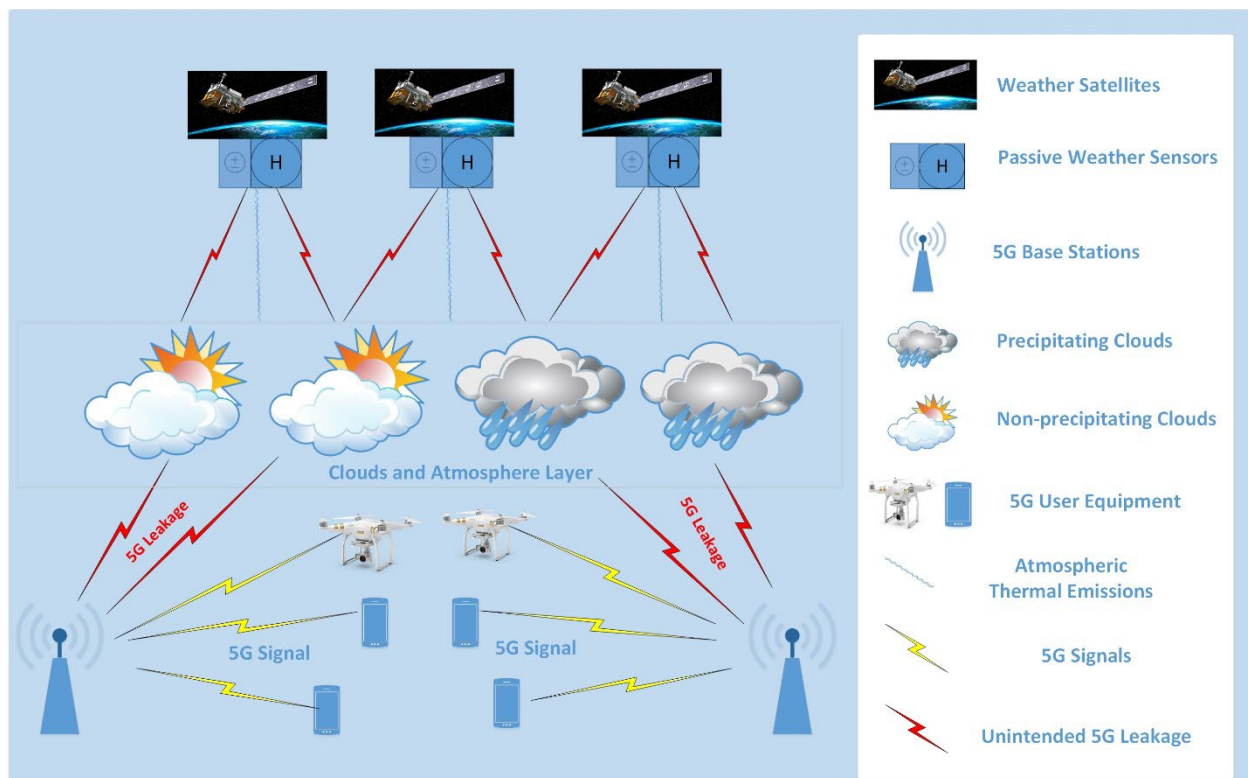


Figure 2: 5G Interference on Passive Weather Sensors on Weather Observation Satellites

The controversy and speculation generated in this unique "spectrum coexistence problem" stems from the diversity of the expertise between core 5G telecommunications

and atmospheric sciences and weather prediction. This lecture will discuss recent work that numerically characterized the impact of 5G leakage on the well-known Super Tuesday Tornado Outbreak data set, and revealed that 5G leakage can indeed affect meteorological forecasting. The specific paper that will be discussed is the following:

M. Yousefvand, C. T. M. Wu, R. Q. Wang, J. Brodie, and N. Mandayam, "Modeling the impact of 5G leakage on weather prediction," in 2020 IEEE 3rd 5G World Forum (5GWF), 2020, pp. 291–296.

Please read the paper that can be found at the link [here](#). It is OK even if you do not completely understand the technical details. We will have a fairly high level discussion of the topic in class. It is also posted on Sakai as Prelecture_Reading_18_Supplement_1.

Impact on Air Traffic Control

Another recent example of widespread attention and controversy related to unintended consequences of newer spectrum for wireless transmissions is the impact of 5G transmissions on the aviation services. This problem of spectrum coexistence has led to an impasse in the rollout of 5G cellphone services and renewed debates between the Federal Communications Commission (FCC) and Federal Aviation Administration (FAA). Specifically, The Federal Communications Commission in [February 2020](#) approved mobile use in the C-Band (3.7-4.2 GHz Band) after considering complaints from the airline industry. The FCC concluded that harmful interference to altimeters was unlikely to occur "under reasonable scenarios" because of the 220 MHz guard band between 5G and altimeter operations and power limits the FCC required for C-Band transmissions.

But airlines weren't prepared for the C-Band launches originally scheduled to begin in December 2021. AT&T and Verizon [agreed to a nationwide delay](#) for about six weeks and to limits on deployment [near airports](#). The deployment limits around airports were initially set to expire in July 2022, but carriers later [agreed](#) to maintain some limits in the airport areas until July 2023.

Altimeters were originally designed decades ago when nearby spectrum bands only contained low-power operations, such as satellites. "This led the early designers of the altimeters to decide they really could ignore their assigned spectrum boundaries, and as a result they allow transmitted energy far outside their band into the receiver," expert Dennis Roberson [explained](#) at a congressional hearing in February 2022.

The altimeter problems spurred the FCC to [launch an inquiry](#) into poorly designed wireless devices that receive transmissions from outside their allotted frequencies. The inquiry could result in new regulations for wireless receivers; the FCC has traditionally imposed limits on transmitters only.

Passive Spectrum Coexistence

Given the push for newer and higher spectrum, in this lecture, we will discuss the emerging issue of passive spectrum coexistence using the above two exemplary scenarios.