U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HEARING CHARTER

Spectrum Needs for Observations in Earth and Space Sciences

Tuesday, July 20, 2021
10:00 am EDT
2318 Rayburn House Office Building and Online via Zoom

PURPOSE

The purpose of this hearing is to review the spectrum needs of relevant science applications within the Committee's purview and consider threats of harmful interference in radio frequency bands used for observations that support weather forecasting and monitoring, climate science, and astronomy. The Committee will examine remote sensing applications in the 23.6-24.0 GHz band (also called the 23.8 GHz band), the potential for harmful interference from operations in the adjacent 24.25-24.45 GHz band (commonly referred to as the 24 GHz band) that was auctioned for new applications by the Federal Communications Commission in 2019, and the consequences of such interference, including degradation of weather forecasting capabilities. Witnesses and Members will discuss opportunities to ensure the needs of incumbent federal users and stakeholders in the scientific community are better accommodated in the federal spectrum management process. We will also consider research and technology development needs to help anticipate, evaluate, and mitigate harmful interference with spectrum used for passive observation.

WITNESSES

- **Mr. Andrew Von Ah,** Director, Physical Infrastructure, Government Accountability Office
- **Mr. David G. Lubar,** Senior Project Leader-Civil Spectrum Management, Civil Systems Group, The Aerospace Corporation
- **Dr. Jordan Gerth,** Honorary Fellow, Space Science and Engineering Center, University of Wisconsin-Madison
- **Mr. Bill Mahoney,** NCAR Associate Director and Director and Director of the Research Applications Laboratory (RAL) at the National Center for Atmospheric Research (NCAR)
- **Ms. Jennifer Manner,** Senior Vice President of Regulatory Affairs, EchoStar Corporation / Hughes Network Systems LLC

KEY QUESTIONS

- What are the implications of spectrum interference for federal science agencies and users of federal science data?
- What options—if any—do incumbent federal users have to mitigate the effects of harmful interference from the 24 GHz band?
- What lessons can we learn from the issues surrounding 24 GHz that can be applied to other spectrum bands of concern?
- What reforms internal to NOAA and NASA and across the federal government should be considered to improve the spectrum auction process?
- Where can research and development be used to maximize efficiency of spectrum usage?

BACKGROUND

The electromagnetic radio frequency spectrum is the medium that enables wireless communications of all kinds, including mobile phones, internet access, radios, satellite communications, GPS, and TV remotes. Various types of technologies operate within distinct "bands" of spectrum, which are divided up into ranges according to their frequency, measured in Hertz (Hz). Spectrum is a finite resource and allocated by the Federal Communications Commission (FCC). While more wireless applications continue to come online, we cannot create more spectrum to serve them. We can only deploy new technologies and strategies that allow for greater efficiency and performance as demand grows.

Many federal agencies are either incumbent users of spectrum or are invested in protecting the spectrum activities of certain private users as part of their mandate. The National Telecommunications and Information Administration (NTIA) within the Department of Commerce (DOC) is charged with representing the spectrum needs of federal agencies with the advice and assistance of the Interdepartmental Radio Advisory Committee (IRAC).[1] IRAC is comprised of representatives from 19 federal agencies that use spectrum, with NTIA serving as the Committee lead. Under a Memorandum of Understanding last updated in 2003, NTIA and the FCC are supposed to work together to resolve domestic policy issues where industry demands for new spectrum may be at odds with federal agency demands.

Because spectrum is a global resource, not bound by international borders, standards for radio spectrum use must be agreed to internationally. Spectrum management proceedings at the international level occur through World Radio Communications (WRC) conferences, which occur every 3-4 years. Prior to each WRC, U.S. federal agencies coordinate, through a preparatory committee, to develop and provide to the Department of State a single U.S. position. A second coordinating document between FCC, NTIA and the State Department (the General Guidance Document) articulates how agencies are to work together on "technical preparations" in advance of some of these international negotiations.

In addition to their participation in IRAC, NASA and NSF also sponsor, under the aegis of the National Academies of Sciences, Engineering, and Medicine, the Committee on Radio Frequencies (CORF).[2] CORF considers the needs for radio frequency requirements and interference protection for scientific and engineering research, coordinates the views of U.S. scientists, and monitors and responds to radio frequency interference and allocation issues as they arise, including by filing public comments in FCC proceedings.

OUT OF BAND EMISSIONS AND SPECTRUM INTERFERENCE

Access to spectrum for new applications has ticked up substantially over the past decade. The FCC has initiated and held several auctions in recent years to make more bands available, in particular for the commercial use of 5G broadband cellular networks. Capabilities like 5G have the potential to help meet increasing needs for advanced wireless and cellular capabilities for personal, commercial, and government purposes. As lower-frequency bands become oversubscribed, 5G operators and others look to higher-frequency bands, where much of the spectrum is already

[1] https://www.ntia.doc.gov/page/interdepartment-radio-advisory-committee-irac
[2] https://www.nationalacademies.org/our-work/committee-on-radio-frequencies

protected for incumbent—often federal—users. This creates pressure to share spectrum and raises the concern for potential interference between new and incumbent users of spectrum.[3]

Utilization of one spectrum band can result in "out-of-band emissions," or the bleeding of signal into nearby or adjacent bands. Interference occurs when multiple electromagnetic waves in the same spectrum are coincident in the same band. Interference can be harmful by degrading service of incumbent users of the band. Federal agencies, including NOAA, NASA, and DoD, have expressed concerns about the auctioning of spectrum bands adjacent to mission-critical bands and the allowable emissions limits, also known as protection limits.[4,5]

24 GHZ

Use of the electromagnetic spectrum between 23.6 and 24.0 GHz is restricted to scientific purposes, for Earth science and radio astronomy observations. Federal regulations and laws and international agreements forbid any other applications from emitting signals within that band.[6]

Based on the fundamental physics of a water molecule, atmospheric water vapor releases energy (radiation) only at certain specific frequencies. The 23.6-24.0 GHz band is protected for Earth-observing satellites—for example, NOAA's Joint Polar Satellite System (JPSS) and NASA's Global Precipitation Measurement (GPM) mission—to "passively" sense, via microwave sensors, water vapor emitting radiation with a frequency of 23.8 GHz in the atmosphere. This is necessary for accurately predicting weather, tracking hurricanes, monitoring sea ice, and understanding climate patterns.[7]

The FCC began the process to auction off the adjacent 24.25-24.45 GHz band in October 2014 with a Notice of Intent.[8] In November 2017, the FCC adopted service rules for the band, which included emission limits of -20 decibel Watts (dBW).[9] The FCC held Auction 102 in March of 2019, which made the 24.25 – 24.45 GHz and 24.75 – 25.25 GHz bands available for purchase. Twenty-nine winning bidders were awarded 2,904 licenses, resulting in about $2 billion in gross proceeds to the FCC.[10]

In November 2019, the WRC adopted more stringent international emissions standards of -33 dBW until 2027, and -39 dBW thereafter.[11] As a signatory to the International Telecommunication Union treaty, the U.S. adopted the new emissions limits in order to conform with new values negotiated at the WRC meeting in 2019 (WRC-19). The FCC is in the process of retroactively applying them to the service rules that companies operating in the 24.25-24.45 band must follow.[12]

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[3] https://www.gao.gov/products/gao-21-26sp
[4] https://www.washingtonpost.com/weather/2019/03/08/critical-weather-data-threatened-by-fcc-spectrum-proposal-say-department-commerce-nasa/
[5] https://spacenews.com/dod-issues-new-rebuke-of-fccs-decision-to-allow-ligado-5g-network/
[6] https://www.nap.edu/catalog/21774/handbook-of-frequency-allocations-and-spectrum-protection-for-scientific-uses
[7] https://www.ntia.doc.gov/files/ntia/publications/ntia_comments_re_24_ghz_emission_limits_et_dkt._no._21-186_gn_dkt._no._14-177.pdf
[8] https://www.fcc.gov/document/noi-examine-use-bands-above-24-ghz-mobile-broadband
[9] FCC Takes Next Steps on Facilitating Spectrum Frontiers Spectrum | Federal Communications Commission
[10] https://auctiondata.fcc.gov/public/projects/auction102
[11] https://www.nature.com/articles/d41586-019-03609-x
[12] https://docs.fcc.gov/public/attachments/DA-21-482A1.pdf

Both CORF[13] and NTIA[14] have submitted public comments in response to the FCC's request for comment on implementing these new service rules.

Weather Forecasting-Related Impacts

NOAA and NASA conducted two studies ahead of the WRC-19 that concluded that the proposed -20 dBW emissions limit would cause significant degradation of weather data and forecast accuracy.[15,16] They concluded an emissions limit as stringent as -52.4 dBW would be necessary to protect weather data. Because dBW is measured on a logarithmic scale, -52.4 dBW is significantly more protective than -33 dBW, which is in turn and significantly more protective than -20 dBW. Furthermore, a number of international studies conducted for WRC-19 came to similarly restrictive numbers.[17]

The Committee held a hearing in April 2019 where former-NASA Administrator Jim Bridenstine reiterated concerns about losing crucial data because of harmful interference.[18] Later in May 2019, before the Environment Subcommittee, former Acting NOAA Administrator Neil Jacobs stated that the interference limits proposed by the FCC "would result in roughly a 77 percent data loss from our passive microwave sounders. This would degrade the forecast skill by up to 30 percent… this would result in the reduction of hurricane track forecast lead time by roughly 2 to 3 days." This would bring forecasting accuracy back to levels we had in 1978.[19]

Technical studies on spectrum interference effects on weather forecasting are largely conducted within federal agencies, to inform internal sensor design and development, as well as sensitive intra-governmental and international negotiations, as in the IRAC and WRC processes described above. The presence of independent, peer-reviewed scientific and technical analyses in the public sphere is therefore limited. Furthermore, the term "harmful interference" is not defined in federal legislation.[20]

Earth System Science

NASA conducts airborne and space-based passive remote sensing to measure radiation that is emitted or reflected from the atmosphere and surface of the Earth in support of basic research on the Earth system.[21] NASA's Joint Agency Satellite Division also develops and launches the weather satellites that NOAA operates, including the GOES and JPSS systems. Within the Earth Science Division, NASA's GPM Microwave Imager (GMI) uses a suite of microwave channels, including one at 23.8 GHz, to measure all forms of precipitation, from moderate and severe rain to ice and snow to study the Earth's hydrosphere (water system) and its contribution to climate

[13] https://ecfsapi.fcc.gov/file/1062569869983/01536758.PDF
[14] https://ecfsapi.fcc.gov/file/106280511404913/NTIA%20Comments%20re%2024%20GHz%20Emission%20Limits%20(ET%20Dkt.%20No.%2021-186%2C%20GN%20Dkt.%20No.%2014-177).pdf
[15] https://science.house.gov/imo/media/doc/Study%20prepared%20by%20NOAA%20and%20NASA%20-%20Results%20from%20NASANOAA%20Sharing%20Studies%20on%20WRC-19%20Agenda%20Item%201.13.pdf
[16] https://science.house.gov/imo/media/doc/Study%20prepared%20by%20NOAA%20and%20NASA%20-%20Additional%20Sharing%20Study%20Results%20Using%20the%20NASA%20GPM%20Sensor.pdf
[17] https://www.nature.com/articles/d41586-019-01305-4?language%5b%5d=en
[18] https://science.house.gov/hearings/a-review-of-the-nasa-fy2020-budget-request
[19] https://science.house.gov/hearings/the-future-of-forecasting-building-a-stronger-us-weather-enterprise
[20] https://ieeeusa.org/wp-content/uploads/2017/07/IEEEUSAWP-HarmfulInterference0712.pdf
[21] https://earthdata.nasa.gov/learn/remote-sensors

and weather patterns.[22] Other NASA Earth science missions need measurements of water vapor at 23.8 GHz to calibrate measurements in other frequency bands; for example, the European Space Agency (ESA)/NASA Sentinel-6 Michael Freilich, which uses radar to monitor sea surface height, has a 24 GHz sensor on board to help achieve ocean height accuracies down to 1.3 inches.[23]

Radio Astronomy

Like weather forecasting, radio astronomy uses passive sensors to detect radiation from space and observe the universe. Because radio telescopes are so powerful, and the signals from phenomena at astronomical distances are so small, even extremely weak interference from an adjacent band can mean a complete loss of scientific observations of celestial bodies. For example, cosmic microwave background (CMB), the radiation left over from the original Big Bang, is only observable for certain bands and even weak interference can block its detection.[24] Radio astronomy is especially impacted by active spectrum use near radio observatories, and to date, astronomers have found some success negotiating with commercial entities emitting nearby.[25]

While NSF advocates for federal radio astronomy equities in the IRAC process, the National Academies Committee on Radio Frequencies (CORF) and the National Radio Astronomy Observatory (NRAO)[26] often file comments directly to the FCC during rulemakings and in international deliberations such as the WRC. Radio astronomers use the protected 23.6-24.0 GHz band to detect ammonia emission—essential in studying how stars form—as well as radiation emitted by active black holes. Importantly, concerns for interference with radio astronomy observations from the 24 GHz auction are limited to certain federally-protected geographic regions; mobile units and base stations need to be placed beyond certain distances from radio observatories in these protected regions or otherwise deployed in coordination with the NRAO.[27]

Past Committee Action

Chairwoman Johnson and Ranking Member Lucas wrote a joint letter to former FCC Commissioner Ajit Pai on March 13, 2019, expressing concerns about the effects of spectrum interference on Earth observation sensors for weather and climate forecasting. The letter urged the FCC not to dismiss the concerns of the science community and requested a delay in the auction of 5G in the 24.25-25.25 GHz spectrum until such concerns were addressed.[28]

Chairman Pai replied in an April 2019 letter, "we have not been presented with *any* evidence of harmful interference from these existing services nor a validated study suggesting that operations in accordance with these rules would adversely affect use of the 23.6-24 GHz allocation, including weather forecasting."[29]

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[22] https://gpm.nasa.gov/missions/GPM/GMI
[23] https://www.nasa.gov/feature/jpl/major-ocean-observing-satellite-starts-providing-science-data
[24] https://www.nsf.gov/news/special_reports/jasonreportconstellations/JSR-20-2H_The_Impacts_of_Large_Constellations_of_Satellites_508.pdf
[25] https://public.nrao.edu/news/nrao-statement-commsats/
[26] The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.
[27] https://ecfsapi.fcc.gov/file/103301405612430/CORF_Above%2095%20GHz_FINAL.pdf
[28] https://science.house.gov/imo/media/doc/Pai%20FCC%20Letter.pdf
[29] https://science.house.gov/imo/media/doc/4.29.19%20Ajit%20Pai%20letter%20to%20EBJ.pdf

On June 19, 2019, Chairwoman Johnson and Ranking Member Lucas wrote to former Commerce Secretary Wilbur Ross and former NASA Administrator Bridenstine requesting information, documents and studies pertaining to out-of-band emissions from the 24 GHz band and the U.S.'s preparation for the WRC-19.[30] In response, the DOC offered a briefing, and NASA provided documents within its purview, including the two NOAA/NASA studies.

On September 30, 2019, Chairwoman Johnson sent a letter to Chairman Pai in advance of WRC-19 and enclosed the NOAA/NASA interference studies. Chairwoman Johnson pointed out that Chairman Pai criticized the quality of the NOAA/NASA studies without providing any technical analyses to support those criticisms and requested documentation on any technical analysis the FCC used to make its assessment.[31]

Chairman Pai did not respond to this letter. Chairwoman Johnson sent a follow-up letter on October 23, 2019. In it, she established that in the absence of any response to her September 30 letter, the FCC must not have any scientific analysis that supports their claims about non-interference.[32]

In December 2019, Chairwoman Johnson and Ranking Member Lucas made a joint request to GAO to conduct a report on the interagency process for the 24 GHz decision.[33] The report will be released publicly on July 19, 2021.

OTHER SPECTRUM BANDS OF CONCERN

The issues associated with the 24 GHz band are not unique. The FCC is considering spectrum auctions that could affect other bands currently protected for scientific purposes and used by federal agencies. These include, but are not limited to:

1675-1680 MHz

The 1675-1680 MHz band is used for the transmission of real-time weather satellite information, including information about severe weather and flooding, from NOAA's Geostationary Operational Environmental Satellites (GOES) to antennae on the ground. The FCC is currently considering a spectrum sharing proposal, commonly known as the Ligado proposal, that would enable non-federal wireless operations in the band.[34] At the request of FCC, NTIA, and OMB, NOAA conducted the Spectrum Pipeline Reallocation Engineering Study (SPRES) to determine the feasibility and implications of sharing the band.[35] The study is funded by the Spectrum Pipeline

[30] https://science.house.gov/imo/media/doc/6.19.19%20Letter%20to%20Secretary%20Ross%20and%20Administrator%20Bridenstine1.pdf

[31] https://science.house.gov/imo/media/doc/9.30.19%20Letter%20to%20FCC%20re%20NOAA%20NASA%20Studies%201.pdf

[32] https://science.house.gov/imo/media/doc/10.23.19%20Follow-up%20FCC%20Letter%20%20.pdf

[33] https://science.house.gov/imo/media/doc/12.10.19%20GAO%20Request%20Letter%2024%20GHz%20_EBJ%20and%20Lucas%20.pdf

[34] https://www.federalregister.gov/documents/2019/05/22/2019-10675/allocation-and-service-rules-for-the-1675-1680-mhz-band

[35] https://acwi.gov/hydrology/stiwg/Meetings/20181213/project%20_spectrum_pipeline_request_1675-1680mhz.pdf

Act and as of July 2021, is said to be undergoing final review. The weather community has expressed concerns about the impacts of interference to weather data.[36]

86-92 GHz

In July 2020, the FCC filed a Notice of Proposed Rulemaking for new uses in the 70/80/90 GHz bands. Within that spectrum, the 86-92 GHz band is allocated specifically for passive Earth Exploration-Satellite and Space Research purposes, in addition to Radio Astronomy services. [37] Weather stakeholders are concerned that interference from new users adjacent to the 86-92 GHz band will harm weather and water information and forecasts.[38]

50.4-51.4 GHz (the "50 GHz band")

The 50 GHz band is important for taking atmospheric temperatures at a range of elevations, which is crucial for numerical weather forecasting.[39] The FCC is considering authorization of this band for the delivery of broadband services. This too is causing great concern among the weather enterprise, as it could impede microwave observations and vertical temperature measurements of the atmosphere at different heights, which is crucial for numerical weather forecasting. Management of the 50 GHz band is expected to be discussed at the WRC meeting in 2023.

5.850-5.895GHz (The Safety Band)

In 1999, the FCC allocated 75 MHz of radio spectrum in the 5.9 GHz band to the Department of Transportation (DOT) for vehicle and infrastructure communications. The band is used for automatic toll collection, speed zone warnings, traffic monitoring, emergency vehicle preemption, research for connected and automated vehicles, and much more. In 2020, the FCC passed a new order dividing the Safety Band in half and giving 45 MHz to unlicensed uses, like Wi-Fi.[40] DOT and many of its stakeholders are worried this change could significantly impact Federal and State users of the band.[41]

SPECTRUM RESEARCH WITHIN FEDERAL AGENCIES

The Wireless Spectrum Interagency Working Group (WSRD) was formed in 2011 to coordinate Federal spectrum R&D across 18 participating agencies and to inventory, coordinate, and make recommendations that promote efficient use of wireless spectrum through advanced technologies and systems.[42] The interagency working group is chaired by NSF and NTIA and operates a team to facilitate access to nationwide testbeds for wireless technologies.[43]

National Science Foundation

[36] https://ecfsapi.fcc.gov/file/10620925629756/AGU-AMS-NWA_WTB-19-116_20-Jun-2019.pdf
[37] https://www.federalregister.gov/documents/2020/07/06/2020-14064/modernizing-and-expanding-access-to-the-708090-ghz-bands
[38] https://www.ametsoc.org/index.cfm/ams/about-ams/ams-position-letters/letter-to-fcc-on-protecting-passive-microwave-sensing-portion-of-spectrum/
[39] https://www.sciencemag.org/news/2019/08/forecasters-fear-5g-wireless-technology-will-muck-weather-predictions
[40] https://www.fcc.gov/ecfs/filing/11202021603352
[41] https://www.transportation.gov/content/safety-band
[42] https://www.nitrd.gov/coordination-areas/wsrd/
[43] https://www.nitrd.gov/coordination-areas/wsrd/awtp/

In 2020, NSF launched the Spectrum Innovation Initiative (SII) which invests in research and research infrastructure focused on spectrum flexibility and agility, near real-time spectrum awareness, and improved spectrum efficiency through secure and autonomous spectrum decision-making. NSF signed an MOU with NTIA and FCC in 2021 to help ensure that NSF's Spectrum Innovation Initiative investments in spectrum research, infrastructure, and workforce development are in alignment with U.S. spectrum regulatory and policy objectives.[44]

NSF is currently in the process of completing a new National Center for Wireless Spectrum Research, which is expected to be awarded later in 2021.[45] NSF also has an Electromagnetic Spectrum Management (ESM) program, which is intended to ensure spectrum access for the scientific community for research purposes.[46] ESM provides technical advice through the NTIA IRAC process, directly to the FCC during rulemakings, and in international deliberations such as the WRC.

National Institute of Standards and Technology (NIST)
The Communications Technology Laboratory (CTL) at NIST supports standards and metrology in advanced communications technologies, including the development of technologies and techniques to measure interference and improve spectrum management. In 2013, NIST signed a MOU with NTIA to establish a Center for Advanced Communication in 2013.[47] In 2015, NIST jointly created the National Advanced Spectrum and Communications Test Network (NASCTN) with both NTIA and Department of Defense. NASCTN is a network of test facilities to support spectrum-related testing, modeling, and analysis.[48] NASA, NOAA, and NSF joined the group in 2018. NASCTN has led to the development of test methods and tools that regulators can use to certify users of shared spectrum to protect against interference. It is also supporting development of forensics tools to monitor wireless spectrum use for the purposes of detecting and "fingerprinting" spectrum use in time and space. However, the small staff is not equipped to independently select and pursue "hot button" spectrum issues, such as debates around future spectrum allocation decisions.[49]

LOOKING FORWARD

Following the 24 GHz saga, in mid-2019 the Commerce Spectrum Management Advisory Committee (CSMAC), the independent advisory board to the NTIA, tasked itself with reporting on whether the US spectrum management approach is optimized for the implementation of a 21st century national spectrum strategy. In January 2020, CSMAC Working Group 1 issued the following statement,

[44] https://docs.fcc.gov/public/attachments/DOC-369633A1.pdf
[45] https://nsf.gov/funding/pgm_summ.jsp?pims_id=505788
[46] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5654&org=MPS&from=home#:~:text=The%20objective%20of%20Electromagnetic%20Spectrum,are%20needed%20for%20research%20purposes
[47] https://www.nist.gov/news-events/news/2013/06/nist-and-ntia-announce-plans-establish-new-center-advanced-communications
[48] https://www.nist.gov/system/files/documents/2017/05/09/2015-03-11_Signed_NASCTN_MOA.pdf
[49] "An Assessment of the Communications Technology Laboratory at the National Institute of Standards and Technology." The National Academies of Sciences, Engineering, and Medicine. 2019.

> *"Our country's current approach for managing the use of spectrum is no longer effectively serving the needs of the entire stakeholder community and would benefit from reform. Moreover, with the increased use of spectrum by all stakeholders, we agree that issued around spectrum sharing and band adjacencies will need to be handled with both speed and skill to ensure that the US is making the most of its critical nation resources."*[50]

Opportunities remain to improve the interagency process and better consider the needs of incumbent federal users in spectrum management in order to reach consensus.

[50] CSMAC Working Group 1 Presentation 07/30/2020 | National Telecommunications and Information Administration (doc.gov)