



Report on Section 374 of the FAA Reauthorization Act of 2018

Prepared by the:

**Wireless Telecommunications Bureau
Office of Engineering and Technology**

Submitted to the:

**Senate Committee on Commerce, Science, and Transportation
House of Representatives Committee on Energy and Commerce
House of Representatives Committee on Transportation and Infrastructure**

August 20, 2020

I. INTRODUCTION

Consistent with Section 374 of the FAA Reauthorization Act of 2018 (Section 374), this report examines whether unmanned aircraft system (UAS) operations should be permitted on the 960-1164 MHz portion of the L-band and 5030-5091 MHz portion of the C-band.¹ Section 374 requires the Administrator of the Federal Aviation Administration (FAA), the National Telecommunications and Information Administration (NTIA), and the Federal Communications Commission (FCC or Commission), to submit to Congress² a report that examines whether to allow the provision of certain UAS communications in these bands, and, if such frequencies are not suitable, to recommend alternative spectrum that may be appropriate.³

Our review of the record developed in this matter indicates the unencumbered 5030-5091 MHz frequencies may support UAS operations, although technical, regulatory, and operational issues may affect the extent of such use. The record does not provide sufficient information to make a definitive assessment regarding the potential barriers to the use of such spectrum. We recommend that the Commission initiate a rulemaking proceeding to develop service and licensing rules enabling UAS use of the 5030-5091 MHz band in collaboration with the FAA and NTIA.

In addition, the record reflects the widely-held view that alternative frequencies licensed under flexible-use service rules⁴ are a promising option for UAS communications, particularly for beyond-visual-line-of-sight and other network-based use cases. The record is insufficient, however, to resolve certain issues including the potential for UAS in the flexible-use bands to cause harmful interference to other operations. We recommend that the Commission continue to review the use of flexible-use bands for UAS and to engage with Federal and private-sector stakeholders to determine whether interference concerns can be addressed adequately through private actions such as industry standards and agreements, or whether regulatory measures are necessary.

Finally, the record reflects significant concern regarding the impacts of potential UAS operations on incumbent aeronautical navigation operations in the 960-1164 MHz band. We do not recommend moving forward with a proceeding to make the 960-1164 MHz band available for UAS operations at this time. We recommend that the Commission continue to study the use of this band for UAS purposes, and to work with the FAA, NTIA, and other stakeholders regarding appropriate UAS rules and policies in the event that circumstances warrant initiating a rulemaking for this band.

II. BACKGROUND

Regulation of Spectrum and UAS. Congress has assigned responsibility for managing the nation's radio spectrum resources to the Commission and NTIA. The Commission is responsible for the administration of non-federal radio frequency (RF) spectrum,⁵ while NTIA administers spectrum for

¹ See FAA Reauthorization Act of 2018, Pub. L. No. 115-254, § 374, 132 Stat. 3186, 3313-14 (2018) (FAA Reauthorization Act).

² Section 374 specifies that the report shall be sent to the Senate Committee on Commerce, Science, and Transportation, the House Committee on Transportation and Infrastructure, and the House Committee on Energy and Commerce. See FAA Reauthorization Act, § 374(a).

³ Specifically, Section 374 provides that, if some of the frequencies in the 960-1164 MHz and 5030-5091 MHz bands are not suitable for beyond-visual-line-of-sight operations, the report should include recommendations of other spectrum that may be appropriate for such operations. *Id.*

⁴ These frequencies, or flexible-use bands, refer to services or spectrum bands for which the Commission's rules do not prescribe specific uses or applications.

⁵ See, e.g., 47 U.S.C. § 301 (providing that “[n]o person shall use or operate any apparatus for the transmission of energy or communications or signals by radio” except under and in accordance with the Communications Act of 1934 (47 U.S.C. §§ 151 et seq.) and with a license granted under its provisions).

federal use (e.g., use by the Department of Defense).⁶ As the majority of the spectrum is allocated to both federal and non-federal use, spectrum management increasingly addresses the use of bands where the FCC and NTIA have joint jurisdiction, including the 960-1164 MHz and 5030-5091 MHz bands identified in Section 374 of the FAA Reauthorization Act.⁷ In addition, the FAA has authority over matters of aviation safety, and it is specifically tasked by statute with developing regulations and standards to integrate UAS into the National Airspace System.⁸ Accordingly, the FCC, NTIA, and FAA have overlapping jurisdiction with respect to the regulation of UAS operations. The Commission adopts rules for new spectrum use through notice-and-comment rulemaking, a process incorporating collaboration with the relevant stakeholders, such as members of the communications industry and the public, as well as with other agencies.⁹ This report reflects our analysis of the developed record with respect to the UAS-related subject matter areas within the Commission’s jurisdiction. We expect that separate reports will be submitted by the NTIA and FAA regarding matters under their respective areas of authority. This report does not contain any material authored or agreed to by the NTIA or FAA. Federal frequency allocations or technical and operational regulation to support the safe integration of UAS in the National Airspace System are within the NTIA’s and FAA’s jurisdiction, respectively.

UAS Access to Spectrum. UAS have vast potential applications in the public and private sectors. Historically, much of the non-federal unmanned aircraft, or UA,¹⁰ use has centered on personal hobbyist use by individuals using unlicensed spectrum to operate small unmanned aircraft over short distances.¹¹ UAS, however, are increasingly being considered for a wide variety of applications and services, including surveillance, search and rescue, newsgathering, infrastructure inspection, and package delivery. Keeping pace with increasing demand for such applications will require that spectrum bands with appropriate characteristics are sufficiently available to meet the needs of numerous users operating in a variety of scenarios. While the vast majority of UAS currently operate on unlicensed spectrum, wide-area, secure wireless network connectivity is required to control, track, and manage UAS operations safely and reliably. As UAS become larger and are used for more complex operations, the need for reliable communications necessarily will increase.

In recognition of the increasing demand for these applications as well as the attendant demand for spectrum necessary to support such functions, the International Telecommunications Union (ITU) has sought to identify spectrum appropriate for UAS operation.¹² The 960-1164 MHz band and the 5030-

⁶ See 47 U.S.C. § 901(c) (directing NTIA to advance policies that “foster[] full and efficient use of telecommunications resources, including effective use of the radio spectrum by the Federal Government, in a manner which encourages the most beneficial uses thereof in the public interest.”); 47 U.S.C. § 305(a) (providing that radio stations belonging to and operated by the United States shall use frequencies assigned to each or to each class by the President).

⁷ As an additional example, the Commission recently adopted a Report and Order that allowed new uses of certain frequencies above 95 GHz that are shared federal/non-federal bands. See *Spectrum Horizons*, ET Docket No. 18-21, First Report and Order, 34 FCC Rcd 1605, 1610, para. 13 (2019).

⁸ See, e.g., 49 U.S.C. § 44802 (“Integration of civil unmanned aircraft systems into national airspace system”); FAA Reauthorization Act, § 341, Pub. L. No. 115-254, 132 Stat. 3186, 3284-87.

⁹ See 5 U.S.C. § 553.

¹⁰ The term “UAS” refers to the entire system (i.e. the aircraft and control system, including the command-and-control link), while “UA” refers to the aircraft only.

¹¹ In addition to use of unlicensed spectrum under 47 CFR part 15, UAS use of spectrum is occurring through several other limited or *ad hoc* options, including: (1) 47 CFR part 95 service channels, including Radio Control Radio Service (subpart C) frequencies, on a non-interference basis; (2) 47 CFR part 97 Amateur Radio Service frequencies, limited to non-commercial purposes; and (3) experimental operations authorized under 47 CFR part 5 on a temporary, non-interference basis.

¹² See, e.g., ITU, Final Acts of the World Radiocommunication Conference (WRC-07) (Geneva, 2007) at 426-427, Resolution 421 (WRC-07), <https://www.itu.int/pub/R-ACT-WRC.8-2007>. The ITU allocates frequency bands to

(continued....)

5091 MHz band were allocated internationally for primary Aeronautical Mobile Route (R) Service (AM(R)S)¹³ by the World Radiocommunication Conference in 2007 and 2012, respectively.¹⁴ These new international allocations expanded the permissible uses in the bands, potentially enabling functions such as UAS command-and-control. Although much of the 960-1164 MHz band is heavily used by incumbent systems, ITU studies examining spectrum for UAS use suggested that it was feasible for UAS to be used in certain portions of the 960-1164 MHz band in some countries.¹⁵ Subsequently, the Commission, in 2015, amended the United States Table of Frequency Allocations (U.S. Table) in section 2.106 of the Commission's rules, to add an AM(R)S allocation at 960-1164 MHz.¹⁶

In 2017, the Commission adopted the AM(R)S designation in the 5030-5091 MHz band by amending the U.S. Table to add an AM(R)S allocation at 5030-5091 MHz.¹⁷ In that proceeding, the Commission noted that the allocation would be “appropriate to satisfy the terrestrial, line-of-sight, spectrum requirements for command and control of UAS in non-segregated airspace,” and it thus adopted the allocation “to support the anticipated growth of UAS and promote their safe operation.”¹⁸

Numerous entities, including governmental entities, standards bodies, universities, and aeronautical and wireless industry groups, are now conducting research and testing with respect to the effective use of the 960-1164 MHz and 5030-5091 MHz bands, among others, for UAS. The FAA currently is studying how to leverage the 960-1164 MHz and 5030-5091 MHz bands for UAS, and it is promoting research into UAS issues.¹⁹ The FCC's Technological Advisory Council (TAC), which provides technical advice to the Commission on a variety of emerging technologies, have included sub-groups specifically tasked with analyzing the communications needs (including spectrum needs) for UAS

(Continued from previous page) _____

various radio services generally on either a worldwide or regional basis and enters these radio services in its International Table as part of the *Radio Regulations*. The ITU revises its International Table and other provisions in its *Radio Regulations* at periodic World Radiocommunication Conferences (WRCs).

¹³ Aeronautical Mobile Route (R) Service (AM(R)S) is an aeronautical mobile service reserved for communications relating to safety and regularity of flight, primarily along national or international civil air routes. 47 CFR § 2.1.

¹⁴ ITU, Final Acts of the World Radiocommunication Conference (WRC-07) (Geneva, 2007) at 415-417, Resolution 417 (WRC-07), 426-27, Resolution 421 (WRC-07), <https://www.itu.int/pub/R-ACT-WRC.8-2007>; ITU, Final Acts of the World Radiocommunication Conference (WRC-12) (Geneva, 2012) at 229-232, Resolution 154 (WRC-12), <http://www.itu.int/pub/R-ACT-WRC.9-2012>. While Section 374 refers to 960-1164 MHz as the L-band and to 5030-5091 MHz as the C-band, we note that the Commission's use of the terms “L-band” and “C-band” in other proceedings can reference a broader or different range of frequencies.

¹⁵ See, e.g., ITU-R, Report ITU-R M.2205 (11/2010), Results of studies of the AM(R)S allocation in the band 960-1164 MHz and of the AMS(R)S allocation in the band 5030-5091 MHz to support control and non-payload communications links for unmanned aircraft systems, at 10, <https://www.itu.int/pub/R-REP-M.2205>.

¹⁶ *Amendment of Parts 1, 2, 15, 25, 27, 74, 78, 80, 87, 90, 97, and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radiocommunication Conference (Geneva, 2007) (WRC-07), Other Allocation Issues, and Related Rule Updates*, ET Docket No. 12-338, Report and Order, Order, and Notice of Proposed Rulemaking, 30 FCC Rcd 4183, 4231, para. 127 (2015) (*WRC 07 R&O and WRC 12 NPRM*).

¹⁷ *Amendment of Part 2, 15, 80, 90, 97, and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radiocommunication Conference (Geneva, 2012) (WRC-12), Other Allocation Issues, and Related Rule Updates*, ET Docket No. 15-99, Report and Order, 32 FCC Rcd 2703, 2718, para. 41 (2017) (*WRC-12 Order*); 47 CFR § 2.106. Use of this allocation is limited to aeronautical systems that operate in accordance with international aviation standards.

¹⁸ *WRC-12 Order*, 32 FCC Rcd at 2718, paras. 41-42. The United States was a lead proponent of this proposal at WRC-12, noting that the allocation and use would be “appropriate as there is minimum use in this band worldwide” and due to the lack of incumbent system deployment in the United States at 5030-5091 MHz. *WRC 07 R&O and WRC 12 NPRM*, 30 FCC Rcd at 4262; 47 CFR § 2.106.

¹⁹ FAA, *Programs, Partnerships & Opportunities* (June 3, 2019), https://www.faa.gov/uas/programs_partnerships/.

applications.²⁰ Several standards bodies similarly are engaging in UAS spectrum studies. For example, a sub-group of the standards development organization RTCA is developing command-and-control standards for the 960-1164 MHz and 5030-5091 MHz bands.²¹ Additionally, work at the 3rd Generation Partnership Project (3GPP) is ongoing to develop standards to enable LTE wireless networks in flexible-use bands to support UAS applications.²²

Section 374 Report Requirements and FCC Implementation. Section 374 of the FAA Reauthorization Act directs the FAA, the NTIA, and the Commission, after consultation with relevant stakeholders, to submit a report—

- (1) on whether unmanned aircraft systems operations should be permitted, but not required, to operate on spectrum that was recommended for allocation for [AM(R)S] and control links^[23] for UAS by the [WRCs] in 2007 (L-band, 960-1164 MHz) and 2012 (C-band, 5030-5091 MHz), on an unlicensed, shared, or exclusive basis, for operations within the [UAS Traffic Management (UTM)²⁴] system or outside of such a system;
- (2) that addresses any technological, statutory, regulatory, and operational barriers to the use of such spectrum; and,
- (3) that, if it is determined that some spectrum frequencies are not suitable for beyond-visual-line-of-sight operations by unmanned aircraft systems, includes recommendations of other spectrum frequencies that may be appropriate for such operations.²⁵

In order to inform this report, the Commission’s Wireless Telecommunications Bureau and Office of Engineering and Technology (collectively, the Bureaus), on November 25, 2019, sought comment on issues relevant to UAS operation.²⁶ In addition to requests for comment on the topics

²⁰ FCC, *Technological Advisory Council*, <https://www.fcc.gov/general/technological-advisory-council>. While the topics generally change year-to-year, each of the most recent incarnations of the TAC has included a UAS sub-group. As the UAS field has emerged, the work of such groups has become more refined, from broad overviews of airborne communications to more focused studies of specific spectrum, usage, and interference scenarios, as reflected in the final TAC meeting presentations from the 2016, 2018, and 2019 groups, respectively: <https://www.fcc.gov/bureaus/oet/tac/tacdocs/meeting12716/TAC-presentations-12-7-16.pdf>; <https://www.fcc.gov/oet/tac/tacdocs/meeting32619/TAC-Presentations-3-26-19.pdf>; and <https://www.fcc.gov/oet/tac/tacdocs/meeting12419/TAC-Presentations-12-4-19.pdf>.

²¹ See RTCA, *SC-228, Minimum Performance Standards for Unmanned Aircraft Systems*, <https://www.rtca.org/content/sc-228>.

²² See, e.g., 3GPP, “UAS-UAV,” Nov. 18, 2019, <https://www.3gpp.org/uas-uav>.

²³ The ITU defines “control link subsystem” as the communication link between the UA and the remote control station that carries telecommands (from the pilot to the UA) and telemetry (from the UA to the pilot). See ITU-R, Report ITU-R M.2171 (12/2009), Characteristics of unmanned aircraft systems and spectrum requirements to support their safe operation in non-segregated airspace, at 2, <https://www.itu.int/en/ITU-R/space/snl/Documents/R-REP-M.2171-2009-PDF-E.pdf>.

²⁴ The UAS Traffic Management system is an air traffic management ecosystem for UAS under development by the FAA, NASA, and other stakeholders. See Federal Aviation Administration, *Unmanned Aircraft System Traffic Management (UTM)*, https://www.faa.gov/uas/research_development/traffic_management/.

²⁵ FAA Reauthorization Act, § 374, Pub. L. No. 115-254, 132 Stat. 3185, 3313-14. Section 374 also provides that the required report does not prohibit or delay use of any licensed spectrum to satisfy control links, tracking, diagnostics, payload communications, collision avoidance, and other functions for unmanned aircraft systems operations.

²⁶ *Wireless Telecommunications Bureau and Office of Engineering and Technology Seek Comment on Unmanned Aerial System Operations in the 960-1164 MHz and 5030-5091 MHz Bands, Pursuant to Section 374 of the FAA*

(continued....)

specifically required by Section 374, the Bureaus sought comment on how various spectrum access methods and infrastructure—existing and planned—might be useful in overcoming potential barriers to UAS deployment.²⁷ Beyond seeking comment on the 960-1164 MHz and 5030-5091 MHz spectrum bands, the Public Notice also asked about actions that could be taken to promote the safe and robust use of licensed, commercial spectrum for UAS operations.²⁸ In particular, the Bureaus acknowledged ongoing studies regarding the use of existing flexible-use mobile networks for UAS command-and-control systems and other functions, such as payload applications, and they requested technical information including deployment scenarios, interference issues, coverage, and operational parameters, among other matters.²⁹

The public comment cycle for this proceeding, GN Docket No. 19-356, concluded on January 27, 2020. The Commission received twenty-two comments and twelve reply comments in response.

III. DISCUSSION

We initially discuss the two most promising options for UAS operations: first, the potential use of the 5030-5091 MHz band, which, due to its unencumbered status, offers the best current option for licensing a dedicated aeronautical band for UAS operations; and second, alternative flexible-use bands that, although not dedicated for aeronautical use, offer a more readily-available option for network-based UAS operations, once outstanding technical issues including interference concerns are addressed. We then assess the 960-1164 MHz band, which is heavily encumbered with critical aeronautical navigation uses and presents, at best, a limited opportunity for UAS operations.

A. The 5030-5091 MHz Band

The Commission allocated the 5030-5091 MHz band for the aeronautical route service to support the anticipated growth of UAS and to promote their safe operation. While the band had been designated for Microwave Landing Systems, a radio guidance system that was intended to be installed at airports to aid aircraft in landing, these systems have been rendered obsolete by the FAA's Wide Area Augmentation System and Global Positioning System and are no longer in use.

Commenters generally support the use of the 5030-5091 MHz band for UAS use, with one commenter noting that the 5030-5091 MHz band is poised to provide beneficial spectrum solutions for the UAS industry.³⁰ The record also indicates, however, that the 5030-5091 MHz band has technical and regulatory issues that need to be resolved before it can be used for UAS. For example, certain commenters raise concerns regarding the types of operation that can be accommodated in the 5030-5091 MHz band. Some maintain that the 5030-5091 MHz band should be restricted to safety-of-life control functions,³¹ while the others support allowing flexibility in the band.³² Other commenters claim that there

(Continued from previous page) _____
Reauthorization Act of 2018, GN Docket No. 19-356, Public Notice, 34 FCC Rcd 11038 (WTB/OET 2019) (Public Notice).

²⁷ Public Notice, 34 FCC Rcd at 11039.

²⁸ *Id.*

²⁹ *Id.*

³⁰ The Boeing Company (Boeing) Comments at 3. *See also* Aerospace Industries Association (AIA) Comments at 5; Airbus Urban Mobility (Airbus UM) Comments 4-5; Aviation Spectrum Resources, Inc. (ASRI) Reply at 7; CTIA-The Wireless Association (CTIA) Comments at 8; Federated Wireless, Inc. (Federated Wireless) Comments at 2; Florida Power & Light Co. (Florida Power & Light) Comments at 1; Lockheed Martin Corp. (Lockheed Martin) Comments at 4; Phirst Technologies, LLC (Phirst) Comments at 3; uAvionix Comments at 1; Boeing Reply at 1; Raytheon Co. (Raytheon) Reply at 4.

³¹ Airbus UM Comments at 5; AURA Networks (AURA) Comments at 5; United Parcel Service, Inc. (UPS) Reply at 9.

are technical issues that would restrict the altitude at which UAs may operate in the band.³³ Such commenters argue that the propagation characteristics of the band make it suitable only for medium altitude flight,³⁴ while others argue that the 5030-5091 MHz band is best suited for high-altitude, long-distance use cases.³⁵ Additionally, certain commenters caution that the Commission should ensure that the introduction of UAS into the band does not adversely affect other services or uses.³⁶

Efforts made by private industry and the FAA are pushing review of these issues forward. RTCA, a standards development organization, has been developing performance standards to support both radio line-of-sight and beyond-line-of-sight networked command-and-control operations to support UAS use in the 5030-5091 MHz band.³⁷ Work on these standards is expected to be finished by the end of 2020. The FAA also has released a Technical Standard Order, which provides minimum performance standards for equipment manufacturers applying for FAA authorization for UAS terrestrial non-networked control system radios operating in the 5040-5050 MHz portion of the band.³⁸

In addition, the Aerospace Industries Association filed a Petition for Rulemaking with the Commission in February 2018.³⁹ The petition includes several proposals, including requests that the Commission designate Frequency Assignment Managers and develop a dynamic frequency assignment process for the 5030-5091 MHz band to ensure spectrum access and efficient reuse. The petition was placed on public notice for comment on April 26, 2018.⁴⁰ Although a large majority of commenters support the petition, opinions differ on the permissible uses and methods of licensing.⁴¹

The technical and regulatory issues related to the 5030-5091 MHz band, including those raised in response to both the rulemaking public notice and the instant Public Notice are complex, and they must be explored by the Commission in a notice-and-comment rulemaking proceeding. Nevertheless, we are

(Continued from previous page) _____

³² See T-Mobile USA, Inc. (T-Mobile) Comments at 3.

³³ AURA Comments at 2 (claiming that the 960-1164 MHz and 5030-5091 MHz bands are “potentially useful for some UAS operations” but have limitations—“especially at low altitudes”).

³⁴ CTIA Comments at 9; T-Mobile Comments at 3-4; Airbus UM Reply at 3.

³⁵ uAvionix Comments at 1; Lockheed Martin Comments at 5; AURA Reply at 3.

³⁶ See Consumer Technology Association (CTA) Comments at 4, n.11 (stating that the Commission must thoughtfully introduce UAS use in the 960-1164 MHz and 5030-5091 MHz bands to ensure that current and planned uses of the bands are not adversely affected); WiMAX Forum Comments at 3 (arguing that careful consideration should be given as to how to adequately ensure that incumbent systems in adjacent bands are protected).

³⁷ RTCA Special Committee 228 (SC-228), established May 20, 2013, is working to develop the Minimum Operational Performance Standards (MOPS) for Detect-and-Avoid (DAA) equipment and a command-and-control Data Link MOPS establishing 960-1164 MHz band and 5030-5091 MHz band solutions. See RTCA, SC-228, *Minimum Performance Standards for Unmanned Aircraft Systems*, <https://www.rtca.org/content/sc-228>. The committee published the first of the Phase 1 documents in September 2016 with the release of DO-362, Command and Control (C2) Data Link Minimum Operational Performance Standards (MOPS) (Terrestrial). Phase 2 of MOPS development is underway to specify DAA equipment to support extended UAS operations and satellite-based command-and-control.

³⁸ See FAA, Technical Standard Order TSO-C213, “Unmanned Aircraft Systems Control and Non-Payload Communications Terrestrial Link System Radios,” <https://ecfsapi.fcc.gov/file/10529188164500/FAA%20TSO-C213.pdf>.

³⁹ See Aerospace Industries Association Petition for Rulemaking, RM-11798 (filed Feb. 8, 2018).

⁴⁰ See *Consumer & Governmental Affairs Bureau Reference Information Center Petition for Rulemakings Filed*, Report No. 3089, Public Notice (CGB Apr. 26, 2018), 2018 WL 1991028.

⁴¹ See [https://www.fcc.gov/ecfs/search/proceedings?q=name:\(\(RM%5C-11798\)\)%20OR%20description:\(\(RM%5C-11798\)\)&sort=date_proceeding_created,DESC](https://www.fcc.gov/ecfs/search/proceedings?q=name:((RM%5C-11798))%20OR%20description:((RM%5C-11798))&sort=date_proceeding_created,DESC).

optimistic that the 5030-5091 MHz band may be used as a platform for UAS operations. The band is unencumbered, technical standards are in the process of being developed, and commenters agree on its use for UAS. Accordingly, we recommend that the Commission consider the applicable technical, statutory, regulatory, and operational barriers and any other challenges regarding the use of the band for UAS in a rulemaking proceeding, in the near term, in close collaboration with the FAA and NTIA.

B. Flexible-Use Bands

Stakeholders also are exploring the extent to which UAS operations may be supported over other licensed spectrum bands that are generally allocated for flexible use and typically used to deploy commercial broadband networks.⁴² Manufacturers, service providers, and public and private UAS operators support using a wide range of bands for UAS operations in addition to spectrum bands dedicated to aeronautical use.⁴³ A number of mobile service providers and other stakeholders currently are developing network-based UAS applications that would operate over commercial networks using flexible-use spectrum.⁴⁴ Several parties also support UAS communications in public safety spectrum.⁴⁵ These various bands offer a promising alternative for UAS communications that would permit operators to leverage and rely upon the capacity and nationwide coverage of existing networks. Because aeronautical operations were not contemplated when the rules were adopted for these bands, however,

⁴² Congress expressly authorized the Commission to allocate spectrum “so as to provide flexibility of use” if (1) “such use is consistent with international agreements to which the United States is a party” and “the Commission finds, after notice and an opportunity for public comment, that . . . (A) such an allocation would be in the public interest; (B) such use would not deter investment in communications services and systems, or technology development; and (C) such use would not result in harmful interference among users.” 47 U.S.C. § 303(y). Section 303(y) “reflects Congressional concern that proposals for the flexible use of spectrum have the potential, if not thoroughly considered, to create interference between services and discourage investment and technical innovation.” *Service Rules for the 746-764 and 776-794 MHz Bands, and Revisions to Part 27 of the Commission’s Rules*, WT Docket No. 99-158, First Report and Order, 15 FCC Rcd 476, 481, para. 10 (2000).

⁴³ See Airbus UM Comments at 3-4; Boeing Comments at 8-9; CTA Comments at 3; CTIA Comments at 10-13; Florida Power & Light Comments at 1; Motorola Solutions, Inc. (Motorola Solutions) Comments at 4 (“Provided that aeronautical mobile service is not specifically prohibited under the FCC’s rules or in the table of allocations, UAS control links should be permitted in existing mobile allocations available for both private radio and commercial operations.”); Phirst Comments at 3-4; Small UAV Coalition Comments at 5-6; T-Mobile Comments at 4-6; Verizon Comments at 2-5; Aircraft Owners and Pilots Association (AOPA) Reply at 3 (stating that the “leveraging of cellular spectrum and infrastructure is a potential solution that the FCC should further explore”); Spectrum Financial Partners, LLC (SFP) Reply at 3-6.

⁴⁴ See, e.g., CTA Comments at 7-8; T-Mobile Comments at 2; Verizon Comments at 3-4, 7; CTIA Reply at 5-6; UPS Reply at 3-4.

⁴⁵ See Motorola Solutions Comments at 3-4; AURA Reply at 2; National Public Safety Telecommunications Council (NPSTC) Reply at 6 (stating that “portions of other spectrum bands may also be beneficial for public safety UAS operations”). As one potential band for such dedicated public safety UAS operations, some parties point to the 4.9 GHz band. In a recent notice of proposed rulemaking to adopt changes to promote greater use of the dedicated public spectrum in the 4.9 GHz band, the Commission proposed to allow manned aeronautical use of Channels 1-5 (currently prohibited by rule), but found it “premature at this time to permit unmanned aerial systems (UAS) to transmit in the 4.9 GHz band.” *Amendment of Part 90 of the Commission’s Rules*, WP Docket No. 07-100, Sixth Further Notice of Proposed Rulemaking, 33 FCC Rcd 3261, 3268, para. 19 (2018). It nevertheless sought comment on the “potential for the 4.9 GHz band to support possible future UAS payload operations,” and some commenters in that proceeding supported permitting public safety UAS operations, including command-and-control, in the band. See, e.g., NPSTC Comments, WP Dkt. No. 07-100, 14-15 (filed July 6, 2018); Utilities Technology Council, the Edison Electric Institute the National Rural Electric Cooperative Association and the GridWise Alliance Reply, WP Docket No. 07-100 (filed Aug. 6, 2018) (“UTC, EEI, NRECA, and GridWise . . . urge[] the Commission to refrain from restricting Unmanned Aerial System (UAS) operations on these channels”). The proceeding remains open at this time.

their use for UAS raises concerns that must be addressed, including the potential for UAS communications to cause harmful interference to other communications.

The flexible-use bands vary with regard to specific technical characteristics and service restrictions, and they likely will present different benefits and challenges to UAS operations that may depend in part on the nature of the operation (such as altitude, location, or type of service) and on the relevant in-band and adjacent band incumbent operations. In addressing such spectrum generally, however, stakeholders identify several advantages of relying on existing flexible-use networks for UAS. The use of networks in these bands is considered a low-cost and more immediately available option for network-based UAS operations compared with building a UAS-specific network over newly-dedicated spectrum in the 960-1164 MHz band or 5030-5091 MHz band.⁴⁶ Various stakeholders further claim that these networks can provide the coverage, performance, and spectrum characteristics suitable to support beyond-visual-line-of-sight operations among other UAS use cases. Stakeholders also claim that flexible-use networks can support the capacity needed for growing UAS demand, economies of scale from standardized mobile broadband network equipment, and spectral and infrastructure efficiencies that result from the network support of multiple services.⁴⁷

The operation of UAS communications over flexible-use or other mobile-use spectrum does present some concerns, however. As an initial matter, the service rules for some flexible-use bands impose restrictions that would limit or prohibit aeronautical operations absent a rule change or waiver. For example, 47 CFR part 22 imposes a prohibition on the airborne use of 800 MHz Cellular service.⁴⁸ Likewise, some public safety spectrum bands are subject to service restrictions that limit or prohibit aeronautical operations.⁴⁹ In addition, several flexible-use bands have restrictions against aeronautical use in the underlying allocation, as reflected in the Non-Federal Table of Allocations.⁵⁰ Absent such restrictions, however, current law does not prohibit the use of flexible-use bands for UAS operations.

Aeronautical use also presents potential interference concerns that warrant additional study. In particular, use of these bands for UAS operations raises the concern that a licensee supporting UAS operations, even if it complies with the applicable technical rules, may cause harmful interference to other licensees with co-channel or adjacent-channel operations. While the Commission established rules in flexible-use bands that are designed to limit harmful interference among licensees, these rules did not contemplate the type of functionality exhibited by UAS. In particular, while the ability to operate at altitude provides a UAS with more favorable line-of-sight propagation conditions, the more favorable

⁴⁶ See, e.g., CTIA Comments at 9-10; General Atomics Aeronautical Systems, Inc. (GA-ASI) Comments at 6; Boeing Comments at 8-9 (asserting that mobile networks may provide the “best chance in the near-term for a workable terrestrial [command and control] system in a significant portion of the United States”); T-Mobile Comments at 5; CTIA Reply at 3-4 (asserting that it will be “many years” before UAS can use either the 960-1164 MHz band or 5030-5091 MHz band and that “licensed commercial wireless spectrum is an ideal alternative that is readily available today”).

⁴⁷ See, e.g., AURA Comments at 8 (“Other spectrum bands [than the 5030-5091 MHz band] with better multipath and foliage penetration will be necessary for low-altitude BVLOS UAS operations. . . . Consequently, the Commission and FAA should establish a regulatory structure that supports the availability of multiple spectrum bands for BVLOS operations.”); CTIA Comments at 10-13; Phirst Comments at 4; T-Mobile Comments at 2-3, 5; SFP Reply at 8-9; UPS Reply at 10-11. See also Attila Takacs, et al., “Drones and networks: Ensuring safe and secure operations,” <https://www.ericsson.com/en/reports-and-papers/white-papers/drones-and-networks-ensuring-safe-and-secure-operations> (“The licensed mobile spectrum serves as the foundation for mobile networks to provide wide-area, high-quality and secure connectivity that can enable cost-efficient drone operations beyond visual line-of-sight range.”).

⁴⁸ See 47 CFR § 22.925.

⁴⁹ See, e.g., 47 CFR § 90.1205(c) (prohibiting aeronautical mobile use in the 4.9 GHz band); NPSTC Reply at 7.

⁵⁰ See, e.g., 47 CFR § 2.106, Table of Frequency Allocations, at 1670-1675 MHz, 1695-1710 MHz, 2305-2310 MHz, 2500-2655 MHz, 3550-3700 MHz.

propagation conditions, in turn, present a higher risk of interference to co-channel and adjacent channel licensees in a variety of scenarios. For example, a signal transmitted from a UA can be visible to multiple terrestrial cell sites of other networks, including sites outside the geographic market in which the UA is operating, which can cause harmful interference that can degrade network performance.⁵¹

Efforts are ongoing to determine the extent of interference problems that a network operator supporting UAS operations may cause either to its own network's performance or to other operations, and to develop, as necessary, techniques to manage and mitigate the increased risk of interference posed by UAS. For example, as part of Release 15 of the technical standard for Long Term Evolution (LTE), 3GPP concluded a study item on the use of LTE for UAS, in which it proposed various interference mitigation strategies.⁵² It is not clear, however, whether the mitigation techniques identified are sufficient or appropriate for the protection of a network operator's own network as well as adjacent networks, including those that do not deploy a UAS technology or are not LTE-based. Some service providers also indicate that they currently are testing UAS operations on their networks for interference among other performance issues. In its comments in this proceeding, for example, Verizon indicates that it is "actively testing how the use of its commercial mobile network to support drone deployments affects its own networks, neighboring licensees in adjacent geographies, and neighboring licensees in adjacent bands to ensure the avoidance of harmful interference."⁵³

As a general matter, the anticipated growth in demand for spectrum to support UAS communications and the range of possible UAS applications support an inclusive approach to spectrum for UAS. We acknowledge that many stakeholders anticipate that significant benefits will accrue from existing flexible-use networks and are not inclined to disagree. These networks and the flexible-use bands over which they operate could enable beyond-visual-line-of-sight and other UAS communications in licensed spectrum earlier than may be possible in either the 5030-5091 MHz or 960-1164 MHz bands.⁵⁴

⁵¹ See, e.g., *Expanding Access to Mobile Wireless Services Onboard Aircraft*, WT Docket No. 13-301, Notice of Proposed Rulemaking, 28 FCC Rcd 17132, 17136, para. 6 (2013).

⁵² See 3GPP Technical Report (TR) 36.777, "Enhanced LTE support for aerial vehicles," available at <https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3231>.

⁵³ Verizon Comments at 7.

⁵⁴ Some stakeholders suggest that UAS command-and-control communications should be restricted, in whole or in part, to spectrum dedicated to aeronautical operations in order to ensure the reliability of these links and the safety of the associated UAS operation. Others assert, however, that networks in flexible-use spectrum can provide the necessary reliability. Compare Airbus UM Comments at 3 (asserting that, for vehicle-to-vehicle communications and vehicle-to-vertiport communications at take-off and landing, "Airbus UM believes that using aviation bands may be necessary to satisfy the need for increased reliability of the link"); GA-ASI Comments at 2-3 (asserting that command-and-control should operate only in aeronautical mobile route service spectrum bands in those cases where "UAS operation poses a credible risk to life" and "the [command-and-control] link provides a necessary mitigation for that risk"); Raytheon Reply at 4 ("While other bands which are multi-purpose might be appropriate to support certain [command-and-control] requirements for some missions, a dedicated band is needed to integrate larger, more sophisticated unmanned aerial vehicles flying longer and higher-altitude missions beyond visual line of sight into the national airspace, including controlled airspace long used for manned flight."), with Small UAV Coalition Comments at 5 ("commercial, licensed networks are not only capable, but particularly well-suited to promoting safe and reliable connectivity for UAS operations, even BVLOS"); CTIA Reply at 12 (asserting that "cellular networks have long been engineered to be secure and resilient to provide uninterrupted connectivity for critical use cases"). There have been several efforts to help resolve the technical issues relevant to UAS support by LTE networks, and work is ongoing. See, e.g., 3GPP, "UAS-UAV," Nov. 18, 2019, <https://www.3gpp.org/uas-uav>; Attila Takacs, et al., "Drones and networks: Ensuring safe and secure operations," <https://www.ericsson.com/en/reports-and-papers/white-papers/drones-and-networks-ensuring-safe-and-secure-operations>; Qualcomm Technologies, Inc., "LTE Unmanned Aircraft Systems: Trial Report," May 12, 2017, <https://www.qualcomm.com/media/documents/files/lte-unmanned-aircraft-systems-trial-report.pdf>; Rafael Amorim, et al., "Measured Uplink Interference Caused by Aerial Vehicles in LTE Cellular Networks," IEEE

(continued....)

The potential interference concerns must be addressed, however. While some parties argue that no change in the flexible-use rules is necessary, we find that we have insufficient data to determine whether the existing rules for the various flexible-use bands are sufficient to address the potential for interference from UAS operations. It is possible that these rules provide inadequate protection of adjacent- or co-channel licensees if UAS operations are deployed. In such circumstance, permitting harmful interference to deployed networks from UAS operations would raise serious public interest concerns, as would solutions that require existing licensees that do not themselves support UAS to make costly modifications to their networks to mitigate interference from another licensee's UAS operations.

We ultimately may conclude that no regulatory action is needed, but we believe that further Commission review of the issue is necessary at this time for the agency to meet its responsibility to manage non-federal spectrum in the public interest.⁵⁵ Accordingly, we are unable on the current record of this proceeding to identify specific alternative frequencies that are appropriate for beyond-visual-line-of-sight operations or other UAS cases. We recommend, however, that the Commission continue to review the use of flexible-use bands and engage with public- and private-sector stakeholders in the near term to determine whether the interference concerns can be addressed adequately through private actions such as industry standards and agreements, or whether it is necessary to take regulatory measures.

C. The 960-1164 MHz Band

The 960-1164 MHz band is used extensively for numerous critical aeronautical navigation systems. These systems are used by private, commercial, and military aircraft to ensure safe passage and collision avoidance both in the air and on the ground at airports. These systems generally consist of transmitting ground stations with corresponding transponders on aircraft. They include: Distance Measuring Equipment, which enable aircraft to measure their relative position; Tactical Air Navigation System, a system similar to Distance Measuring Equipment, designed for use by military aircraft but also used by civilian aircraft; Secondary Surveillance Radar, used for air traffic control purposes; Automatic Dependent Surveillance Broadcast, and Universal Access Transceivers, used for collision avoidance and air traffic control; the Traffic Alert and Collision Avoidance System, used for collision avoidance; and the Vehicle Movement Area Transponder System, which provides the location of both ground vehicles and aircraft for collision avoidance at airports.⁵⁶

The extensive use of the 960-1164 MHz band and the critical nature of the systems currently operating in the band require careful consideration before any new systems or technologies are introduced. It is essential that incumbent navigation systems are protected and that new systems that are introduced into the band do not cause harmful interference. The private aeronautical community also expresses concern about introducing UAS operations in the band. For example, commenters such as Boeing and Airbus UM point out the widespread use and sensitive nature of critical aeronautical navigation systems in the 960-1164 MHz band.⁵⁷ Commenters argue that UAS use of the band presents

(Continued from previous page) _____
Wireless Communications Letters, Vol. 7, No. 6 (Dec. 2018),
<https://ybn.aau.dk/ws/portalfiles/portal/293138377/08369158.pdf>.

⁵⁵ The Communications Act, in expressly authorizing the allocation of spectrum for flexible use, provides that such allocations are appropriate only if the Commission finds, *inter alia*, that “such use would not result in harmful interference among users.” 47 U.S.C. § 303(y)(2)(C).

⁵⁶ Both internationally and within the United States, the 960-1164 MHz band is allocated jointly to the aeronautical radionavigation service and AM(R)S. The aeronautical radionavigation service allocation at 960-1164 MHz (which extends to 1215 MHz) is reserved on a world-wide basis for the operation of airborne electronic aids to air navigation and any directly associated ground-based facilities. Operations pursuant to the AM(R)S allocation must comply with international standards, including specific recommendations on coexistence with the aeronautical radionavigation service. 47 CFR § 2.106, footnotes 5.327A, 5.328.

⁵⁷ See, e.g., Airbus UM Comments at 5 (stating that “it will be very difficult to find usable spectrum in the band due to all of the current uses,” including incumbent navigation aids, surveillance systems and collision avoidance

(continued....)

significant challenges given the heavy incumbency⁵⁸ and that any policy proposal that threatens to cause harmful interference to incumbents or to strand existing investments in infrastructure should not be pursued.⁵⁹ Wireless industry commenters likewise express reservations. CTIA, for example, agrees that the spectrum is already heavily used by aviation systems, such as navigation aids, surveillance systems, and collision avoidance systems necessary for safe manned-aircraft operations, and that use of the band for UAS would need to be location and altitude dependent to protect such incumbent systems from harmful interference.⁶⁰ While some commenters suggest that UAS should be permitted in the 960-1164 MHz band⁶¹ others also caution that, to the extent that the 960-1164 MHz band remains under consideration for UAS use, any such use must be subject to strict interference protections for in-band safety-of-flight operations as well as navigation systems.⁶²

The record submitted in response to the Public Notice underscores the difficulties in using the 960-1164 MHz band for UAS operation. We recognize the challenges to any additional use of the band, and we agree that careful consideration must be given to protect incumbent uses. The addition of other services in this critical safety-of-life band potentially could compromise the national airspace system (NAS) and interfere with the systems it depends upon during flight, take-off, and landing, including other airport operations. As one commenter notes, potential uses for the 960-1164 MHz band would require considerable technical review and potentially may impose additional burdens on users reliant on other systems operating on that spectrum.⁶³ Accordingly, while we will continue to examine the potential for UAS use in the band, we do not recommend moving forward with a proceeding at this time in light of the current difficulties associated with using these frequencies for UAS. When the Commission determines that circumstances favor a rulemaking proceeding, however, we will work closely with the FAA and NTIA as well as collaborate with other stakeholders to determine whether and how UAS use can be accommodated in the 960-1164 MHz band.

(Continued from previous page) _____
systems); Boeing Comments at 3, 7-8 (arguing that the 960-1164 MHz band has “extensive existing use of, and investment in, numerous systems used for the safety of the flying public and national security”). *See also* SFP Reply at 2-3.

⁵⁸ *See, e.g.*, Aireon LLC (Aireon) Comments at 4-5; AURA Comments at 2-4 (stating that incumbents’ use of mission-critical services makes it difficult for UAS operators to use the 960-1164 MHz band for command-and-control); Phirst Comments at 3; uAvionix Comments at 1 (stating that the 960-1164 MHz band is extensively used for navigation and surveillance making interference avoidance a challenge); Airbus UM Reply at 3-4; ASRI Reply at 8; AURA Reply at 2-3.

⁵⁹ Boeing Comments at 3. *See also* Aireon Comments at 5 (asserting that the Commission should explore other spectrum given the potential harmful impact on critical aviation safety services”).

⁶⁰ CTIA Comments at 9.

⁶¹ *See, e.g.*, Airbus UM Comments 4-5; Telecommunications Subcommittee of the American Petroleum Institute (API) Comments at 4; CTA Comments at 3; Federated Wireless Comments at 2; Phirst Comments at 3; Small UAV Coalition Comments at 6-7; T-Mobile Comments at 2; uAvionix Comments at 1; Federated Wireless Reply at 1-2 (stating that concerns regarding incumbent operations are not barriers to intensive UAS use of the 960-1164 MHz band).

⁶² *See* Aireon Comments at 4-6 (arguing that any operations in the 960-1164 MHz band must adequately protect incumbent operations); AOPA Reply at 3 (stating that non-interference must be assured for incumbent systems that are heavily relied upon for manned aviation flight safety); Boeing Comments at 3, 7 (arguing that “any regulatory regime that enables UAS operations in the band must ensure that existing operations are not impacted”); GPS Innovation Alliance (GPSIA) Comments at 2-3 (noting that the international allocation for the 960-1164 MHz band includes conditions designed to protect operations in adjacent bands); Boeing Comments at 7 (asserting that “interference must not just be avoided, but . . . altogether prevented”); UPS Reply at 14 (asserting that it is critical that the introduction of UAS operations in the band does not impair incumbent uses).

⁶³ UPS Reply at 14 n.31.

IV. RECOMMENDATION

The record confirms the rapid growth in the number and variety of UAS operations and the potential benefits from new UAS applications in both the public and private sectors. To realize this potential will require addressing the need of UAS operations for spectrum to enable command-and-control links, telemetry, payload, and other communications. The 5030-5091 MHz band as well as certain flexible-use bands are potential options for supporting such UAS communications. The 5030-5091 MHz band appears to offer promise for intensive UAS use because it is unencumbered, but that band poses some technical and regulatory issues that require further review before UAS operations may be permitted. In addition to the 5030-5091 MHz band, many stakeholders have expressed interest in a wide range of other spectrum bands, including existing flexible-use spectrum bands used by commercial broadband mobile providers, with varying characteristics that may present different challenges and benefits for UAS operation. Although these networks offer the potential to support wide-area UAS operations across the nation in the near term, they also present interference concerns and other operational questions that must be addressed. While we are encouraged by studies and work to date concerning the potential of flexible-use spectrum and LTE technology to support UAS, we find that further review of these issues will be required to ensure that integration of UAS occurs in a manner that serves the public interest. Finally, the 960-1164 MHz band is encumbered with numerous critical aeronautical navigation uses, making the deployment of UAS in the band challenging. While some comments suggest that UAS operations should be permitted in this spectrum, the record largely reflects concern regarding the possible impacts of such use to incumbents in the 960-1164 MHz band.

Given these considerations, we recommend that the Commission initiate a rulemaking proceeding to develop service and licensing rules enabling UAS use of the 5030-5091 MHz band. In addition, we recommend that the Commission continue review of the potential benefits and technical challenges associated with the use of the flexible-use bands. The Commission should engage with stakeholders to determine whether UAS flexible-use spectrum can support UAS operations without harmful impact or whether regulatory measures are necessary. Finally, because of the existing incumbency and the potential impact of additional services in the 960-1164 MHz band, we recommend that the Commission continue to monitor ongoing activities involving use of this band for UAS purposes.