

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Amendment of Part 90 of the	)	WP Docket No. 07-100
Commission's Rules	)	
	)	

**COMMENTS OF THE
NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES**

The National Academy of Sciences, through its Committee on Radio Frequencies (hereinafter, CORF),¹ hereby submits its Comments in response to the Commission's Seventh Further Notice of Proposed Rulemaking (FCC 20-137) in the above-captioned docket ("*Seventh Further Notice*"). In these Comments, CORF discusses proposed aeronautical mobile use of spectrum at 4940-4990 MHz. CORF has long supported the thoughtful sharing of spectrum among services, when such sharing is practical. However, an aeronautical service transmitting down to Earth is the worst-case scenario in regard to potential interference problems for Radio Astronomy Service ("RAS") observatories, as recognized in a number of footnotes to the U.S. Table of Frequency Allocations. CORF recommends against revision of the Commission's rules to authorize aeronautical use of the 4.9 GHz band. If, however, the Commission chooses to allow such use in its rules, then protections for the RAS that were proposed in the *Sixth*

¹ See the Appendix for the membership of the Committee on Radio Frequencies.

Further Notice of Proposed Rulemaking in this proceeding,² along with other protections, must be adopted to minimize harmful interference to radio astronomy observatories.

I. Introduction: The Role of Radio Astronomy and the Unique Vulnerability of Passive Services to Interference.

CORF has a substantial interest in this proceeding because it represents the interests of the passive scientific users of the radio spectrum, including users of the RAS bands. RAS observers perform extremely important yet vulnerable research.

As the Commission has long recognized, radio astronomy is a vitally important tool used by scientists to study our universe. It was through the use of radio astronomy that scientists discovered the first planets outside the solar system, circling a distant pulsar. Ongoing radio observations of nearby extrasolar planets aim to detect the presence of a magnetic field that could be a prerequisite for life, since current theory suggests that the lack of a Martian magnetic field to protect it against solar storms and cosmic rays might explain why it is relatively barren compared to the Earth, which has a strong magnetic field. The Nobel Prize winning discovery of pulsars by radio astronomers has led to the recognition of a widespread population in the Milky Way Galaxy of rapidly spinning neutron stars with gravitational fields at their surface up to 100 billion times stronger than on Earth's surface. Subsequent radio observations of pulsars have revolutionized the understanding of the physics of neutron stars and resulted in the first experimental evidence for gravitational radiation, which was

² *Amendment of Part 90 of the Commission's Rules*, WP Docket No. 07-100, *Further Notice of Proposed Rulemaking*, 33 FCC Rcd 3261, 3262, para. 2 (2018) (*Sixth Further Notice*).

recognized with the awarding of another Nobel Prize.³ Within our own solar system, radio astronomy observations of the Sun have been used for more than half a century to aid in the prediction of terrestrial high-frequency radio propagation. Radio astronomy has also enabled the discovery of organic matter and prebiotic molecules outside our solar system, leading to new insights into the potential existence of life elsewhere in the Milky Way Galaxy. Radio spectroscopy and broadband continuum observations have identified and characterized the birth sites of stars in the Milky Way, the processes by which stars slowly die, and the complex distribution and evolution of galaxies in the universe. The enormous energies contained in the enigmatic quasars and radio galaxies discovered by radio astronomers have led to the recognition that most galaxies, including our own Milky Way, contain supermassive black holes at their centers, a phenomenon that appears to be crucial to the creation and evolution of galaxies. Synchronized observations using widely spaced radio telescopes around the world give extraordinarily high angular resolution, far superior to that which can be obtained using the largest optical telescopes on the ground or in space.

This critical science undertaken by RAS observers, however, cannot be performed without access to interference-free bands. Notably, the emissions that radio astronomers receive are extremely weak—a radio telescope receives less than 1 percent of one-billionth of one-billionth of a Watt (10^{-20} W) from a typical cosmic object. Because radio astronomy receivers are designed to pick up such remarkably weak signals, radio observatories are particularly vulnerable to interference from in-band emissions, spurious and out-of-band emissions from licensed and unlicensed users of

³ Radio astronomy measurements led to yet another Nobel Prize winning discovery of the cosmic microwave background (CMB), the radiation left over from the original Big Bang.

neighboring bands, and emissions that produce harmonic signals in the RAS bands, even if those human-made emissions are weak and distant.

Of particular concern in this proceeding is protection of RAS observations in the 4.9 GHz band. As stated in footnote 57 of the *Sixth Further Notice*, radio astronomy observations in the 4.9 GHz band are extremely useful in studying the brightness distributions of objects such as ionized hydrogen clouds surrounding young stars; remnants of supernovae, which mark the cataclysmic end of stars; and ejecta traveling at nearly the speed of light from black holes in the nuclei of galaxies. Such observations allow scientists to construct detailed maps of such phenomena, to understand their structures and dynamics, and to derive physical parameters from the sources, such as their total masses. Observations of radio emissions from neutron stars and black holes are particularly sensitive to interference due to their natural variability, and one cannot just re-observe such phenomena at a later time. The current benefits of this scientific research, obtained through years of work and substantial federal investment, as well as future benefits, must be protected.

In recognition of the importance of the radio astronomy research done in the 4.9 GHz band, Footnote US385 states that “[i]n the bands . . . 4950-4990 MHz, every practicable effort will be made to avoid the assignment of frequencies to stations in the fixed and mobile services that could interfere with radio astronomy observations” at certain RAS observatories listed therein, and further states that “every practicable effort will be made to avoid assignment of frequencies in these bands to stations in the aeronautical mobile service that operate outside of those geographic areas, but which may cause harmful interference to the listed observatories.” Similarly, Footnote US342

states that “all practicable steps shall be taken to protect the radio astronomy service” at 4950-4990 MHz and also states that “[e]missions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service.” Footnote US342 does not limit that protection to only the RAS observatories listed in Footnote US385.

II. CORF Opposes Authorizing Aeronautical Use at 4940-4990 MHz.

CORF has long supported thoughtful use of spectrum sharing among services. However, an aeronautical service transmitting down to Earth is the worst-case scenario in regard to potential interference problems for radio astronomy observatories, as recognized in Footnotes US342 and US385. Accordingly, CORF opposes revising Section 90.1205(c) of the Commission’s rules to remove the prohibition on aeronautical use of 4940-4990 MHz (“4.9 GHz band”). In reviewing filings in this comment cycle, the Commission should be mindful that brief statements of support for such a rule revision are easy to make but, by themselves, do not constitute strong evidence that widespread adoption of aeronautical use would ensue, nor do they provide a strong basis for revising this long-standing rule. Yet the costs of revising the rule, particularly without substantial protections for RAS, could include the loss of use of this important band for scientific research.

III. If the Commission Chooses to Authorize Aeronautical Use of the 4.9 GHz Band, It Should Also Enact Protections for RAS.

As noted above, CORF opposes revising the Commission’s rules to authorize aeronautical use of the 4.9 GHz band. However, if the Commission chooses to so revise

its rules, then any revision should include provisions to protect RAS observations at 4950-4990 MHz from interference. Such protections were proposed in the *Sixth Further Notice*. Additional protections should be added if the Commission also authorizes the leasing of this band by states.

The *Sixth Further Notice* recognized the significant risks of interference to RAS facilities from aeronautical transmissions at 4.9 GHz and proposed specific means of protecting RAS. While terrestrial services are quite capable of causing interference to sensitive RAS facilities, aeronautical uses are even more capable of such effects, due to the breadth of the geography “seen” by an airborne transmitter and the ease with which such transmissions can be made directly into the RAS receiver due to lack of intervening obstructions.⁴ Thus, preventing line-of-sight transmission is critical to any practical sharing of the 4.9 GHz band between RAS and aeronautical mobile uses.

The line-of-sight issue is triggered when aircraft fly above the horizon of an RAS observatory. This is a function of flight altitude, but also of local geography and the presence or absence of terrain-shielding mountains. The *Sixth Further Notice* proposed (at para. 20) a maximum operational altitude of 1,500 feet above ground level.⁵ CORF supports that proposal as a simple method for minimizing line-of-sight transmissions into RAS facilities, provided that operation is prohibited within 80.5 kilometers of an observatory listed in footnotes US385 or US161,⁶ as also proposed in para. 22 of the

⁴ See Footnote US342.

⁵ The size of the exclusion zone (currently a radius of 80.5 km) is based on the line-of-sight, which is a function of operational altitude. If the maximum operational altitude is revised, the exclusion zone radius would also need to be revised to protect radio astronomy observatories.

⁶ Procedures should also be defined for notification when and if additional RAS observatories commence observing at this frequency band.

Sixth Further Notice.⁷ A clear and unambiguous limit eliminates the proliferation of confusing, site-specific altitudes close to RAS facilities that may be easily violated, even unintentionally. It also limits the risk associated with disagreements over the effectiveness of terrain-blocking features in a particular scenario.

The other core method for protecting RAS observations is sufficient frequency separation from the active transmissions. Accordingly, CORF supports the proposal in para. 15 of the *Sixth Further Notice* to limit aeronautical use of this band to Channels 1-5, i.e., 4940-4945 MHz, thus creating a “guard band” of separation from the RAS allocation at 4950-4990 MHz. The Commission should also be mindful of the issue of out-of-band emissions by requiring the specific emission mask in the rule Section 90.1219(b) proposed in the *Sixth Further Notice*.

CORF also supports other protections for RAS proposed in the *Sixth Further Notice*, such as the proposal in para.19 therein to prohibit the use of the band by unmanned aerial systems. Such vehicles are likely to be used by non-professionals and thus are more likely to inadvertently or purposely violate other limitations such as distance and frequency separations.⁸

⁷ Section 90.1219(f) as proposed in the *Sixth Further Notice* referred to the Allen Telescope Array (“ATA”). If the Commission adopts such a rule section in this proceeding, it should revise the coordinates for the ATA to use 40° 49' 03" North latitude, 121° 28' 24" West longitude. That proposed rule section also provided for waivers of the geographical restriction but required any such waiver to be served on the affected observatory. For sake of ease, CORF recommends that such service be sent to the National Science Foundation Spectrum Management Unit, esm@nsf.gov. RAS representatives must have at least 30 days to respond to such waiver requests.

⁸ There has also been discussion in this proceeding of use of this band by robotic devices. Due to the limited number of exigent circumstances in which such robots are anticipated to be used for public safety purposes, as well as the remote location of radio astronomy observatories, CORF does not anticipate a significant likelihood of interference to RAS observations from public safety use of robots. However, this may not be the case with private or commercial use of such robots. Accordingly, CORF recommends that any robotic use of this band be limited to public safety agencies and subject to general coordination requirements, except in obviously

CORF also supports the requirement in proposed Section 90.1219(d) in the *Sixth Further Notice* that applicants provide a description of their operations to demonstrate that such operations will protect radio astronomy (and other terrestrial uses) from interference. This requirement would help focus applicants on the requirements of Section 90.1219 and provide some basis for evaluating their compliance.⁹ More broadly, though, CORF notes that the *Sixth Further Notice* was proposed (at paras. 27-28) to require frequency coordination for new operations in the 4.9 GHz band. CORF urges the Commission to include a requirement to coordinate with RAS when the proposed facilities (including terrestrial facilities) would operate within 80.5 kilometers (50 miles) of radio astronomy sites listed in § 2.106 US385.¹⁰ Such coordination should be through the National Science Foundation's Spectrum Management Unit, esm@nsf.gov.

Additional requirements for protection of RAS would be required if the Commission chooses to enact the leasing framework proposed in the *Seventh Further Notice*. Specifically, certain rights of use of the 4.9 GHz band should not automatically transfer from a state lessor to its lessee. The Commission noted in paragraph 27 of the *Seventh Further Notice* that if:

a State Lessor has been granted a waiver of the section 90.1205(c) aeronautical prohibition, that right is not transferable to a lessee. A lessee seeking to engage in

exigent circumstances. In such exigent circumstances, a public safety agency that would otherwise be subject to coordination requirements should notify the impacted observatory as soon as possible.

⁹ This requirement would also provide a basis for the Commission to impose special conditions or restrictions on individual licensees, where necessary to reduce the risk of interference to RAS operations, as set forth in the Section 90.1219(g) proposal in the *Sixth Further Notice*. The Commission should clarify that it may impose special conditions not just at the time of issuing an authorization, but subsequently as well, if interference to RAS results from the authorized aeronautical operations.

¹⁰ Of course, there may be emergency situations where such coordination is not possible. Radio astronomers are good citizens and would be unlikely to object to interference resulting from legitimate public safety aeronautical use during and immediately following a natural disaster or other critical emergency.

aeronautical mobile operations must submit a request for waiver accompanied by a sufficient technical justification and an exhibit demonstrating the State Lessor's support for the waiver.

That should remain the same in the present context. That is, if a state leases use of its 4.9 GHz band authorization to a private or commercial entity, that lease should not automatically include the right to aeronautical use if the leased territory includes a protected radio astronomy site or that territory is within the required coordination distance of such a site. Commission rules should provide that in such cases, a waiver must be obtained on behalf of the lessee, and the lease should require explicit acknowledgement of the specific radio astronomy observatory, as well as a requirement that the lessee comply with all rules designed to protect RAS from aeronautical uses. Commission rules should also provide that the lessor remains liable for compliance with these rules. In addition, in cases where the leased territory includes a protected radio astronomy site, or that territory is within the required coordination distance of such a site, the Commission's rules should provide that, prior to the commencement of the lease, notice of leased aeronautical use must be provided to the National Science Foundation's Spectrum Management Unit, esm@nsf.gov, with the names and contact information of both the lessor and the lessee. These requirements are critical to ensure that no one "drops the ball" during the leasing process regarding protection of RAS and that subsequently, it is relatively easy to contact the parties in case of interference.

IV. Conclusion.

The Commission has long recognized the risks of interference to RAS from aeronautical use of the 4.9 GHz band. For the same reasons, CORF generally opposes aeronautical use of the 4.9 GHz band. However, if the Commission chooses to revise its

rules to remove the current prohibition on such use, it must enact the protections discussed above in order to provide an adequate level of protection to RAS.

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

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