Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Spectrum Horizons	)	ET Docket No. 18-21
	)	
James Edwin Whedbee Petition for Rulemaking to Allow Unlicensed Operation in the 95-1,000 GHz Band	)	RM-11795

COMMENTS OF PROF. JOSEP M. JORNET ON FCC-CIRC1903-01 (DRAFT FIRST REPORT & ORDER)

INTRODUCTION

I am Josep M. Jornet, Associate Professor with the Department of Electrical Engineering at the University at Buffalo, The State University of New York, and the Director of its Ultra-broadband Nano Communication and Networking Laboratory. My current research interests are in Terahertz-band communication networks, Nano-photonic wireless communication, Electromagnetic nanonetworks, Intra-body Wireless Nanosensor Networks and the Internet of Nano-Things.[1] I have been an applicant for and have received FCC experimental licenses above 95 GHz. These comments are based on my direct experience seeking such licenses. These comments are my personal views and do not necessarily represent the views of University at Buffalo or any entity of the State of New York.

These comments deal only with the experimental licensing issue in the draft and do not address the new unlicensed bands which I generally support. On February 21, 2019, Chairman Pai announced this historic pending FCC decision opening significant spectrum above 95 GHz for the first time saying, "I'm also proposing to add a new experimental license type that would permit experimental use on any frequency from 95 GHz to 3 THz, with no limits on geography or technology".[2] This is an admirable goal and I fully support it. However, based on both past experience in experimental license deliberations above 95 GHz and a detailed reading of the draft it is questionable whether the provisions in the draft are adequate to achieve this goal.

[1] https://ubnano.tech/team_members/josep-miquel-jornet/
[2] https://www.fcc.gov/news-events/blog/2019/02/21/behold-ides-march

HOW UPPER SPECTRUM DIFFERS

The spectrum above 95 GHz differs in key ways from lower spectrum which is generally regulated with concepts dating from the first decades of the 20th Century:

• Almost all spectrum above 95 GHz is shared with federal users[3] and thus subject to parallel jurisdiction of FCC and NTIA under Sections 301, 305 and 902(b)(2)(K) of the Communications Act ("*Act")* of 1934 as amended.[4] It is thus also subject to the Commission's Memorandum of Understanding with NTIA ("*MOU*").[5]

• The propagation at these frequencies is fundamentally different than propagation at lower bands including the fact that upward paths at low elevation angles from terrestrial transmitters to satellites have extremely high path losses unprecedented at lower bands.[6]

• Due to the presence of many molecular resonances above 95 GHz, there is great interest for passive sciences for both Radio Astronomy (RA) and Earth Environment Sensing Satellites (EESS) in this spectrum. In current spectrum allocations, passive allocations have a negligible impact at lower bands but have a major impact here.[7]

• The millimeter and submillimeter wavelengths at these frequencies permit practical use of antennas design approaches, *e.g.,* quasioptical antennas, that are not feasible at lower frequencies with their much longer wavelengths. Variants of the MIMO technology that enables 5G could control emissions at these frequencies in unintended directions where there are sensitive passive satellites.

• There is no record showing any consideration of opportunity costs issues when the current high density of passive allocations above 95 GHz were made decades ago as technology for communications use of this spectrum was not available or even generally expected.

---

[3] In lower spectrum about 30-40% is shared G/NG

[4] 47 U.S.C. §§ 301,301, 902(b)(2)(K)

[5] *Memorandum of Understanding between FCC and* NTIA (January 31, 2003)) (http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-230835A2.pdf)

[6] *Supplemental Submission of the mmWave Coalition*, ET Docket No. 18-21, November 30, 2018, at Fig. 8-9 (The data presented was computed by the Ultra-broadband Nano Communication and Networking Laboratory.)

[7] *Ibid.* at p. 6-8

ACTUAL EXPERIENCE IN EXPERIMENT LICENSE APPLICATION AT THESE BANDS

In Attachments I and II we have actual experimental licenses issued by the Commission in File Number 0753-EX-ST-2018 for an experiment in our laboratory at 220-260 GHz. The first license was issued on May 20,2018 and Special Condition 3 states:

> "Operation is not authorized to transmit any frequencies in the following bands:
> a.226-231.5 GHz
> b.250-252 GHz "

In a statement attached to the application[8] the information required by §5.85(a)(2) for applications in a passive band was included as well as a request that the application be treated as a "new technology" under §7(a) of the Act[9] with respect to the burden required by "Any person or party (other than the Commission) who opposes a new technology".

There was no dialogue between the applicant and FCC or NTIA before this license was issued with this condition. While the protection of RA facilities is controlled by coordination pursuant to the terms of §2.107 of the FCC Rules[10], protection of EESS spectrum use is handled in a process which is much less transparent.
While the only formal appeal of this condition would have been a petition for reconsideration under §1.106[11], the expected delay of such a request would have been impractical for this type of experimentation. Fortunately, the Commission staff agreed to informally discuss the matter with NTIA. We pointed out that while these frequencies were used for satellite-based sensing of atmospheric ozone, the only satellite presently taking such measurements was in an NGSO orbit and thus was not even visible from our campus most of the day.

About 45 days after initial license, we received the second license in Attachment II. This time the license included a performance based restriction to prevent impact on the passive:

> "The University of Buffalo shall not transmit in the 226-231.5 GHz or 250-252 GHz frequency bands when the NASA Aura spacecraft (NORAD designation 28376 or international spacecraft ID 2004-07-15) is within horizon-to-horizon view of the testing location. "

---

8 https://apps.fcc.gov/els/GetAtt.html?id=208954&x=.
9 47 U.S.C. § 157(a)
10 47 C.F.R. § 2.107
11 47 C.F.R. § 1.106

While one might argue that the "horizon-to-horizon view" restriction was excessive due to the very high path losses at low elevation angles, this was a reasonable compromise that addressed both satellite protection and ability to perform the experiment.

However, the license also contained the following text in Condition 5:

> "The University of Buffalo shall be aware that NASA will not concur on any requests for operational use of the 226-231.5 GHz or 250-252 GHz frequency bands; this concurrence for experimental operation in a passive allocation is being provided on a one time only basis."

The "one time only basis" restriction is not explained nor is only legal basis given for it. Does this mean that experiments in such spectrum have only a single opportunity with not opportunity of extension independent of spectrum interference potential.

Another problem with present policy on experimental licenses at these frequencies is the inability to plan for what spectrum is feasible for even short experiments. For example, published research shows that in 2013 scientists in Germany at the Karlsruhe Institute of Technology (KIT), the Fraunhofer Institute for Applied Solid State Physics, and the University of Stuttgart, created a wireless connection between a transmitter and a receiver that were 20 meters apart at a frequency of 237.5 GHz and achieved a data rates in excess of 100 Gb/s in 2013.[12] Would such an experiment be allow under FCC's jurisdiction under either present policy or the policy in the *Draft?* While this center frequency is not protected by US246, it is in a band with a coprimary "EARTH EXPLORATION-SATELLITE (passive)" which raises uncertainty whether this experiment could have been done in US territory.

TOWARDS MORE TRANSPARENT FCC/NTIA COORDINATION OF SPECTRUM HORIZONS LICENSES

The previously mentioned §2.107 focuses on interaction between RA facilities and FCC applications to resolve interference questions related to license applications. It has been effective in resolving such issues in a timely and mutually satisfactory way. But is has no counterpart for licenses applications that impinge on EESS spectrum.

When another applicant for spectrum in the Spectrum Horizons bands sought to discuss a pending experimental license application with NASA staff, he received the following reply with a NASA official who participates on IRAC/FAS review of licenses in G spectrum and G/NG shared spectrum:

[12] Lily Hay Newman, "A New Record for Terahertz Transmission", *IEEE Spectrum,* Nov. 2013 (https://spectrum.ieee.org/telecom/wireless/a-new-record-for-terahertz-transmission)

> "While I would have no difficulty in speaking to you on this subject, the problem is one of policy. It is NASA policy to not allow ANY emissions in ANY bands allocated to exclusive passive use such as given in US246 and RR No. 5.340. For this reason I had no choice but to object to the subject application."[13]

So a key issue here is what is the controlling "policy" for experimental licenses above 95 GHz? Is it the NASA policy referred to in the quote above or the vision of Chairman Pai quoted earlier or something in between?

The *Draft* states,

> Spectrum Horizons Licenses in this range will only be granted on a non-interfering basis, only following coordination with federal users (including bands identified/allocated for passive services) through the NTIA and the IRAC process, and unless a sufficient methodology for preventing harmful interference is detailed, such operations will not be permitted.[14]

There is no indication of what type of "a sufficient methodology for preventing harmful interference" is needed or if it will ever be made available to applicants. In the past this "coordination with federal users the NTIA and the IRAC process" has been a dialogue between FCC staff and federal employees at NTIA and agencies that participate in IRAC. This is a process that was developed for lower frequencies where federal use was generally law enforcement and national security related and thus could not be readily discussed with the private sector. This may not be the best way to protect passive scientific systems as in EESS. There is no general policy permitting the license applicant to participate or even be informed about the status of such dialogue.

The *Draft* goes on to say

> The mmW Coalition is concerned that the current IRAC coordination process "effectively gives a government agency the ability to veto an experimental application regardless of whether there is any potential for real-world interference to government spectrum users." mmWave Comments at 9-10. The mmW Coalition urges NTIA to require IRAC participants to show, within a reasonable timeframe, that the proposed experimental license will have an adverse impact on the operations of federal systems. *Id.* We note that the FCC/NTIA coordination process is subject to a Memorandum of Understanding between the two agencies and any consideration of changes to the established process is beyond the scope of this proceeding.[15]

The *MOU* referred to in the above quote has been cited earlier and it does not even mention the IRAC! Yet the combination of the quote from the NASA official above and Condition 5 in the license shown in Attachment II strongly implies a commonly held view

---

[13] Message dated December 5, 2014. Full text was provided to FCC staff prior to the commencement of this proceeding.

[14] *Draft 1stR&O* at para.13

[15] *Draft* at fn.39

of a *de facto* veto of experimental license frequencies by individual IRAC member agencies. While perhaps this issue was beyond the ability of the primary authors of the draft to change, it certainly is within the ability of the Commission *en banc* to change.

Anything near the announced goal of Chairman Pai of "a new experimental license type that would that would permit experimental use on any frequency from 95 GHz to 3 THz, with no limits on geography or technology" will be impossible in either large segments of the spectrum or in any large contiguous block of spectrum unless the coordination of applications with the federal agencies responsible for EESS starts meeting some minimal levels of transparency. In the remainder of these comments I offer suggestions of how that might be done.

SPECIFIC SUGGESTIONS

As mentioned earlier, the §2.107 coordination policy for RAS site protection has been effective and noncontroversial. It allows direct dialogue between the applicant and those responsible for the passive system that needs protection so that compromises can be worked out that are mutually acceptable. For example, the Snowshoe Ski Resort in West Virginia was able to reach agreement for a special low power Wi-Fi system for its guests that operates within the National Radio Quiet Zone as a result of direct dialogue.[16]

The mmWave Coalition in its comments to NTIA in the National Spectrum Strategy proceeding (which are also cross-filed in this proceeding) addressed the issue of experimental licenses in the spectrum above 95 GHz. I support their proposal that only the minimal necessary restrictions to protect operating EESS systems should be allowed:

> "mmWC urges NTIA to amend the Redbook provisions to coordination on experimental license to provide that conditions on licenses greater than 95 GHz recommended by NTIA to FCC must be the minimum conditions needed to protect G systems during the duration of the license and at the location of the license and that consideration of possibly creating precedents are inappropriate in the experimental license coordination process."[17]

[16] https://www.npr.org/sections/alltechconsidered/2013/10/08/218976699/enter-the-quiet-zone-where-cell-service-wi-fi-are-banned

[17] millimeterWave Coalition Comments, NTIA Docket No. 181130999-8999-01, January 22, 2019 at p. 13-14 (Cross filed in Docket 18-21) (https://ecfsapi.fcc.gov/file/10130024051912/mmW%20Coalition_NTIA%201%2019%20RFC%20comm%20final.pdf)

The Commission recently addressed the issue of experimental licenses in passive spectrum when it adopted the present §5.85(a)(2) which was adopted in July 2015.[18] At that time it stated:

> We observe that in those instances in which an experimental applicant had requested use of a passive band, OET staff in coordination with NTIA undertook a case-by-case review of the application and imposed specific conditions on the applicant, as warranted, to minimize the potential that the experiment would cause harmful interference to passive service(s) that use that band.

There *might* be blocks of spectrum above 95 GHz that contain classified uses that would complicate a transparent coordination process. An initial FCC/NTIA policy that creates a transparent scheme for o*nly parts* of the spectrum in the 95 GHz - 3 THz region would allow a test of improved transparency while protecting any possible classified uses as well as even the approximate frequencies of such uses. For example, the initial policy could identify a few 50 or 100 GHz wide blocks of contiguous spectrum that would be subject to a transparent coordinate process as a limited term policy experiment. No explanation is needed why certain blocks and not other blocks were chosen.

Upper spectrum experimenters and developers need better transparency in the. availability of spectrum for new experiments. In this spectrum region equipment is scarce and usually very expensive at this time. This sometimes necessitates the use of passive spectrum for initial experiments even if nearby spectrum would be suitable in the long term. This was the apparent goal of the current terms of §5.85(a)(2).

[18] *Memorandum Opinion and order and Further Notice of Proposed Rulemaking*, Docket 10-236, July 6, 2015 at para. 7 (https://docs.fcc.gov/public/attachments/FCC-15-76A1.pdf)

CONCLUSIONS

This current experimental license process is not working well in this spectrum is not working well as indicated in Attachments I and II. I urge FCC and NTIA to review how it can be improved to get closer to the dialogue possible for RA cases. Experimentation in spectrum above 95 GHz is vital to new applications of radio technology and for US national leadership in such technology.

The suggestions I have outlined above will speed the processing of experimental license applications as well as stimulate experimentation and product development in this upper spectrum to the benefit of US technical leadership in the world.

/s/

Josep M. Jornet
Department of Electrical Engineering
University at Buffalo,
The State University of New York
Buffalo, NY, 14260

cc: Rachael Bender
Erin McGrath
Will Adams
Umair Javed
William Davenport
Eric Burger
Julius Knapp
Brian Butler
Michael Ha
Ira Keltz
Nicholas Oros
Aspasia Paroutsas
Jamison Prime
Karen Rackley
Hugh Van Tuyl

Attachment I - May 20, 2018 Experimental License for University of Buffalo

Prof. Josep Jornet, 230 Davis Hall, Buffalo, NY 14260-4200,

United States of America
FEDERAL COMMUNICATIONS COMMISSION
EXPERIMENTAL
SPECIAL TEMPORARY AUTHORIZATION

EXPERIMENTAL	WM9XXI
(Nature of Service)	(Call Sign)
XT FX	0753-EX-ST-2018
(Class of Station)	(File Number)

NAME University at Buffalo, The State University of New York

This Special Temporary Authorization is granted upon the express condition that it may be terminated by the Commission at any time without advance notice or hearing if in its discretion the need for such action arises. Nothing contained herein shall be construed as a finding by the Commission that the authority herein granted is or will be in the public interest beyond the express terms hereof.

This Special Temporary Authorization shall not vest in the grantee any right to operate the station nor any right in the use of the frequencies designated in the authorization beyond the term hereof, nor in any other manner than authorized herein. Neither the authorization nor the right granted hereunder shall be assigned or otherwise transferred in violation of the Communications Act of 1934. This authorization is subject to the right of use of control the Government of the United States conferred by Section 706 of the Communications Act of 1934.

Special Temporary Authority is hereby granted to operate the apparatus described below:

Purpose Of Operation:
To make propagation measurements in the 200 GHz region in order to develop better propagation models and to study the effectiveness of different modulation types for broadband data.

Station Locations
(1) Buffalo (ERIE), NY - NL 42-57-28; WL 78-48-53

Frequency Information

Buffalo (ERIE), NY - NL 42-57-28; WL 78-48-53

Frequency	Station Class	Emission Designator	Authorized Power	Frequency Tolerance (+/-)
220-260 GHz	FX	40G0F1D	3162 W (ERP)	0.00001 %

Special Conditions:
(1) Licensee should be aware that other stations may be licensed on these frequencies and if any interference occurs, the licensee of this authorization will be subject to immediate shut down.
(2) In lieu of frequency tolerance, the occupied bandwidth of the emission shall not extend beyond the band limits set forth above.

This authorization effective May 20, 2018 and
will expire 3:00 A.M. EST November 21, 2018

FEDERAL COMMUNICATIONS COMMISSION

Special Conditions:

(3) Operation is not authorized to transmit any frequencies in the following bands:
a.226-231.5 GHz
b.250-252 GHz

(4) Stop Buzzer, Josep Jornet at (716) 645-1607, email: jmjornet@buffalo.edu

Attachment I - July 11, 2018 Experimental License for University of Buffalo

Prof. Josep Jornet, 230 Davis Hall, Buffalo, NY 14260-4200,

United States of America
FEDERAL COMMUNICATIONS COMMISSION
EXPERIMENTAL
SPECIAL TEMPORARY AUTHORIZATION

EXPERIMENTAL	WM9XXI
(Nature of Service)	(Call Sign)
XT FX	0753-EX-ST-2018
(Class of Station)	(File Number)

NAME University at Buffalo, The State University of New York

This Special Temporary Authorization is granted upon the express condition that it may be terminated by the Commission at any time without advance notice or hearing if in its discretion the need for such action arises. Nothing contained herein shall be construed as a finding by the Commission that the authority herein granted is or will be in the public interest beyond the express terms hereof.

This Special Temporary Authorization shall not vest in the grantee any right to operate the station nor any right in the use of the frequencies designated in the authorization beyond the term hereof, nor in any other manner than authorized herein. Neither the authorization nor the right granted hereunder shall be assigned or otherwise transferred in violation of the Communications Act of 1934. This authorization is subject to the right of use of control the Government of the United States conferred by Section 706 of the Communications Act of 1934.

Special Temporary Authority is hereby granted to operate the apparatus described below:

Purpose Of Operation:
To make propagation measurements in the 200 GHz region in order to develop better propagation models and to study the effectiveness of different modulation types for broadband data.

Station Locations
(1) Buffalo (ERIE), NY - NL 42-57-28; WL 78-48-53

Frequency Information

Buffalo (ERIE), NY - NL 42-57-28; WL 78-48-53

Frequency	Station Class	Emission Designator	Authorized Power	Frequency Tolerance (+/-)
220-260 GHz	FX	40G0F1D	3162 W (ERP)	0.00001 %

Special Conditions:
(1) Licensee should be aware that other stations may be licensed on these frequencies and if any interference occurs, the licensee of this authorization will be subject to immediate shut down.
(2) In lieu of frequency tolerance, the occupied bandwidth of the emission shall not extend beyond the band limits set forth above.
(3) Stop Buzzer, Josep Jornet at (716) 645-1607, email: jmjornet@buffalo.edu

This authorization effective July 11, 2018 and
will expire 3:00 A.M. EST November 21, 2018

FEDERAL COMMUNICATIONS COMMISSION

Page 1 of 2

Special Conditions:

(4) All operations granted on an experimental basis shall be on an unprotected, non-interference basis to authorized stations.

(5) The University of Buffalo shall be aware that NASA will not concur on any requests for operational use of the 226-231.5 GHz or 250-252 GHz frequency bands; this concurrence for experimental operation in a passive allocation is being provided on a one time only basis.

(6) The University of Buffalo shall not transmit in the 226-231.5 GHz or 250-252 GHz frequency bands when the NASA Aura spacecraft (NORAD designation 28376 or international spacecraft ID 2004-07-15) is within horizon-to-horizon view of the testing location.

(7) This authorization SUPERSEDES the previously issued authorization with the same call sign and file number: amend conditions.