Before the
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
Washington, D.C. 20230

In the Matter of

National Spectrum Strategy Implementation	**)** **)**	Docket NTIA-2023-0003**)**

Comments of
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Summary

These comments propose a variety of new approaches for implementing the National Spectrum Strategy. These range from identifying and addressing the present legislative limits of NTIA's authority over the recurring issue in G/NG spectrum policy. While legislation could be helpful, historically legislation has had trouble keeping up with this rapidly changing technology. Thus nonlegislative approaches are proposed where plausible. A key issue is to recognize the history of agencies "endruns" against NTIA's actions by improving agency confidence in NTIA's objectivity and making new technical resources available to NTIA and FCC for more objective and timely analysis of the technical issues in spectrum sharing. As part of this, the review of NTIA spectrum decisions under §902(b)(2)(A) must be made more credible to federal spectrum users through a procedure that the agencies have had a role in designing and find credible. There are key lessons

to be learned from the recent 5G/radar altimeter dispute so that such conflicts are addressed at an earlier stage to consider the overall public interest as well as credible technical issues.

Author

Dr. Marcus is a retired senior executive from FCC who worked at the agency for nearly 25 years in both the spectrum policy and enforcement areas. He frequently interacted with NTIA on G/NG spectrum policy issues, participated in IRAC ad hoc subcommittees and attended IRAC meetings from time to time. His qualifications are well known to NTIA and the Commission[1].

He is now associated with Northeastern University[2] as both Principal Research Scientist, Institute for the Wireless Internet of Things and Adjunct Professor/Lecturer, Department of Electrical and Computer Engineering. He has taught graduate courses on spectrum policy at MIT, Virginia Tech and Northeastern University. In 2010-23 he was Department Editor for Spectrum Policy & Regulatory Affairs of *IEEE Wireless Communications Magazine*, writing many articles[3] on national and international spectrum policy issues. He was elected a Fellow of the IEEE in 2004 "for leadership in the development of spectrum management policies" and awarded the IEEE Communications Society's 2013 Award for Public Service in the Field of Telecommunications "For pioneering spectrum policy initiatives that created the modern unlicensed bands for applications that have changed out world".

As a Mike Mansfield Fellow[4] he worked in Japan for a year at the Japanese spectrum regulator (now MIC) and related institutions. He has also been a consultant to the European Commission and the Singapore regulator (now IMDA).

[1] https://web.archive.org/web/20041118191250/hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-243463A1.pdf
[2] https://coe.northeastern.edu/people/marcus-michael/
[3] https://orcid.org/0000-0002-4521-9079
[4] https://mansfieldfellows.org/about-the-fellowship/

These comments are not being submitted on the behalf of any client or employer and are being submitted purely in the public interest without any remuneration.

Introduction

When I first joined FCC in 1979, I participated in two interagency groups: the Interdepartment Radio Advisory Committee (IRAC) and the National Communications Security Committee[5] (NCSC) – which I believe has been renamed since that time. In theory both these were interagency groups that each advised a senior federal official who held delegated authority from the President. The Assistant Secretary of Commerce for Communications and Information (Administrator, NTIA) had delegated authority[6] from the President for "assigning frequencies to radio stations belonging to and operated by the U.S., or to classes thereof". The Secretary of Defense was designated[7] as the Executive Agent for Communications Security and The Director of the National Security Agency (DIRNSA) executed those responsibilities for the Secretary of Defense[8]. Both of these groups were involved in creating rules that applied to various federal agencies: IRAC for spectrum use by the agencies and NCSC for procurement and use of encryption technology for classified information.

It soon became clear that these 2 groups operated in very different ways. IRAC discussed spectrum policy issued that affected the federal agencies and seemed to be making virtually all the decisions with the NTIA staff spectrum staff virtually acting as its secretariat. Only in very rare exceptions did NTIA question or change the IRAC "recommendations". By contrast, the

[5] https://www.documentcloud.org/documents/22538546-the-national-communications-security-committee
[6] NTIA, *Manual of Regulations for Federal Radiofrequency Spectrum Management*, Section 1.1 (https://www.ntia.gov/sites/default/files/2023-11/1_2021_edition_rev_2023.pdf)
[7] Executive Order 12036, January 1978,
[8]https://www.transportation.gov/sites/dot.gov/files/docs/dotorders/DOT1610.2_National%20Communications%20Securit%20Committee%20%28NCSC%29%20Policy%20and%20National%20Communications%20Security%20%28COMSEC%29%20Issuance%20System_10-Feb-84.pdf
https://www.documentcloud.org/documents/22538546-the-national-communications-security-committee

NSA staff was very interested what NCSC member thought about possible policy changes that would affect their agencies and their operations but it was very clear that DIRNSA was the final decision maker and would take their concerns into account.

I was puzzled by this dichotomy until I started to review the history of IRAC. The two most helpful articles are the 1962 paper[9] by Nobel Laureate Ronald Coase and the 1945 paper[10] by IRAC vice-chair E.M. Webster. The Webster paper describes how "(t)he IRAC came into existence June 1, 1922". Coase explains,

> "After the first Radio Conference (in 1922) the Chairman of the Conference suggested to the Secretary of Commerce that interested government departments should form a committee to examine the use of radio frequencies for government broadcasting."

Webster describes the first recognition of IRAC's function in the federal government:

> First official recognition of the authority of the IRAC in connection with allocations came about in 1927 when, in a letter to the Secretary of Commerce, the President justified the action of the Committee in assuming the responsibility for advising him in regard to frequency assignments for the government.

I have not been able to find any reference or documentation that there was ever a formal delegation of frequency assignment power to IRAC. However, Coase states:

> "when the Federal Radio Commission was formed in 1927, it was IRAC which came to exercise the powers reserved to the President for assigning frequencies to Federal Government departments."

So, the initial seven departments in IRAC basically created it in 1922 to fill a vacuum that existed due to radio technology that outpaced federal legislation on spectrum policy and without

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[9] Ronald H. Coase, "The Interdepartment Radio Advisory Committee," 5 *J. Law and Econ* 17 (1962)
(This paper has a currently valid copyright and is not available for free to all users. A related draft paper by Coase written around the same time, but not made publicly available until 1995, is available from RAND Corp as https://www.rand.org/pubs/drafts/DRU1219.html)

[10] E. M. Webster, "The Interdepartment Radio Advisory Committee," *Proc. IRE*, Vol. *33*, No. 8, pp. 495-499, Aug. 1945

any legislation or clear executive action IRAC took *de facto* authority to regulate G spectrum. Executive Order 10995[11], February 16, delegated the President's §305 "authority to assign radio frequencies to Government agencies" to Director of the Office of Emergency Planning – an Executive Office of the President predecessor to NTIA. But Coase observed

> "In fact, IRAC, has continued to assign radio frequencies to Government departments, although it decisions are subject to the approval of the Director of Telecommunications Management"

It is unclear if much has changes since Coase wrote these observations more than 60 years ago except that Director of Telecommunications Management was replaced by the Office of Telecommunications Policy (OTP) in 1970 and then by NTIA in 1978. During my attendance at IRAC meetings as an FCC staffer I had heard IRAC members tell NTIA staffers that NTIA's role was to take IRAC decisions and "sell them" to FCC and Congress. It is important that NTIA clearly establishes its role as the President's agent for spectrum policy just as in my experience decades ago in NCSC DIRNSA made clear. But in the period in which I attended IRAC meetings as an FCC staffer, I heard on repeated occasions from staffers of IRAC member agencies that one agency can not tell another agency what to do, implying spectrum decisions were up to IRAC not NTIA.

I was once honored to have the opportunity to discuss OTP's approach to spectrum policy with the late Justice Scalia who had been OTP General Counsel in 1971-72. He told me that OTP Director Whitehead chose to let IRAC make spectrum policy decisions but kept an eye on pending matters in IRAC and would directly contact cabinet members if "their IRAC members got out of line". Further, since Whitehead was located in the White House he had direct access to high officials who could support his viewpoint with cabinet members on their agencies' policy

[11] https://irp.fas.org/offdocs/eo/eo-10995.htm

viewpoints in IRAC. Such direct access was lost in 1978 when the G spectrum management function was moved to the new NTIA in the Commerce Department. However, this was not initially a major problem until G/NG spectrum matters became more contentious when spectrum-based technologies began to have a rapidly growing impact on both civil society and the national economy.

The Legislative Problem with NTIA's Present Authority

US spectrum policy was very narrow, focusing on ship radio and broadcasting, until the 1927 Radio Act[12]. Only with advancing technology enabling access to more and more spectrum and new uses for radio technology did it become apparent that more general legislation was needed. The 1927 set up the FCC's predecessor, the Federal Radio Commission with legislation that seems like a first draft of Title III of the later Communications Act of 1934. It also started the formal G/NG regulatory dichotomy with this text in §6:

> Radio stations belonging to and operated by the United States shall not be subject to the provisions of sections 1,4, and 5 of this Act. All such Government stations shall use such frequencies or wave lengths as shall be assigned to each or each class by the president.

[12] PL 632, 69th Congress.

The 1927 Act also attempted to deal with G/NG interference with this provision in §25:

> **SEC. 25. At all places where Government and private or commercial radio stations on land operate in such close proximity that interference with the work of Government stations can not be avoided when they are operating simultaneously such private or commercial stations as do interfere with the transmission or reception of radio communications or signals by the Government stations concerned shall not use their transmitters during the first fifteen minutes of each hour, local standard time.**
>
> **The Government stations for which the above-mentioned division of time is established shall transmit radio communications or signals only during the first fifteen minutes of each hour, local standard time, except in case of signals or radio communications relating to vessels in distress and vessel requests for information as to course, location, or compass direction.**

In the 1934 Act, the provisions for the President authority over G stations were modified very slightly:

> Radio stations belonging to and operated by the United States shall not be subject to the provisions of sections 301 and 303 of this title. All such Government stations shall use such frequencies as shall be assigned to each or to each class by the President.

The only changes here were the new section numbers for the Title 3 powers of FCC replacing the sections number of the 1927 Act and deleting the reference to "wave lengths" since technical advances had resulted in general use of "frequencies" to denominate spectrum.

The provisions for dealing with G/NG interference issues were recodified in 1934, *unchanged*, in the present §323 which has never been amended at all since 1934:

> (a) At all places where Government and private or commercial radio stations on land operate in such close proximity that interference with the work of Government stations cannot be avoided when they are operating simultaneously, such private or commercial stations as do interfere with the transmission or reception of radio communications or signals by the Government stations concerned shall not use their transmitters during the first fifteen minutes of each hour, local standard time.
> (b) The Government stations for which the above-mentioned division of time is established shall transmit radio communications or signals only during the first fifteen minutes of each hour, local standard time, except in case of signals or radio communications relating to vessels in distress and vessel requests for information as to course, location, or compass direction.

While these provisions *may* have been adequate in 1927 and 1934, they raise serious problems with the complexity of today's spectrum use. The 214 words of §305 are minuscule compared the 2600 words in §303 – the enumeration of FCC's spectrum regulatory authority--which had been amended 16 times since 1934! While the power of the President to regulated radio use by federal agencies may not need to as detailed as the FCC's powers, since regulation federal agencies is not subject of the Administrative Procedures Act[13] and its procedure safeguards, the current minimal enumerated spectrum powers of the President leads to real ambiguities on NTIA's valid jurisdiction in exercising those pwers.

Consider both the long standing Ligado/GPS controversy as well as the 6G/radar altimeter controversy. In the Ligado/GPS case the GPS transmitters were authorized under the President's §305 authority although most of the receivers that *might* receive interference were privately owned. Ligado is an FCC-licensed system. The likelihood of interference in this case was clearly related to receiver performance that is not directly addressed for this type of system in either FCC's[14] or the President's authority.

In the 5G/radar altimeter case, 5G is almost always licensed by FCC under its §303 authority as are almost all of the US radar altimeters -- except those in federal agency aircraft. The neat §301/§305 dichotomy doesn't make any sense here. In reality, spectrum issues impact the FAA's mandate over aviation safety but the law at present is silent on whether NTIA has any role here or oversight over FAA's view of spectrum issues.

[13] 5 USC §§551,706

[14] FCC's sole present statutory authority to regulate receiver interference vulnerability is in 47 USC §302a(a) which is limited to "minimum performance standards for home electronic equipment and systems to reduce their susceptibility to interference from radio frequency energy". (Emphasis added)

In the longstanding dispute over possible receiver-generated interference to aircraft Instrument Landing System receivers[15], FAA has *some* statutory authority to make "hazard determinations" under the terms of 49 USC § 44718[16] -- a statute does not provide *any role* for NTIA to determine whether FAA is technically valid in its concerns to press for burden sharing that may be in the public interest. Indeed, when this issue caused a major delay in FM licensing and transmitter upgrade approvals around 1990, top NTIA leadership refused to have any role in even mediating between FCC and FAA.

I urge NTIA to consider requesting a legislative change to delete the present woefully anachronistic terms of §323, preferably replacing it with *some* legislative guidance on how the President and FCC resolve their respective rules under the §301/§305 jurisdiction dichotomy. The use of the verbatim text of §25 of the Radio Act of 1927 in today's statute on this key issue highlights the need to update key legislation to reflect the realities of today's technology and today's ubiquitous spectrum uses.

If it is not feasible for NTISA to request a clarification of its role in 49 USC § 44718, it should seek an MOU with FAA analogous to its MOU with FCC that define the roles of each agencies in the case of mutual jurisdiction.

OMB Circular A-11 Issues and Possible Future Role in NSS

I observe that *neither* the November 13, 2023 National Spectrum Strategy document *nor* the Presidential Memorandum mention either OMB or the role of OMB Circular No. A–11[17] in

[15] ITU, Compatibility between the sound-broadcasting service in the band of about 87-108 MHz and the aeronautical services in the band 108-137 MHz Recommendation, ITU-R SM.1009-1 (10/1995) https://www.itu.int/dms_pubrec/itu-r/rec/sm/R-REC-SM.1009-1-199510-I!!PDF-E.pdf

[16] This provision was adopted in PL 100-223 in 1987. Did FAA and NTIA ever discuss this legislation before it was adopted?

[17] OMB, CIRCULAR NO. A–11 PREPARATION, SUBMISSION, AND EXECUTION OF THE BUDGET, August 2023 https://www.whitehouse.gov/wp-content/uploads/2018/06/a11.pdf

federal spectrum policy. Section 31.11 of Circular No. A–11 deals with "Radio spectrum-dependent communications-electronics systems". A-11 is discussed briefly in Redbook §10.1[18] but there is little information on the NTIA website other than 2 CSMAC documents.[19]

Sharing G/NG spectrum if possible has been a national goal for two decades now. The simple technical fact is that it is difficult for a system that was designed on the assumption of having exclusive access to spectrum. NTIA's Incumbent Informing Capability (IIC)[20] is an admirable initiative in designing new federal systems to facilitate spectrum sharing and should be included as an issue in A-11 review. A-11 already includes this discussion of sharing :

> Whether the system will share spectrum with other Federal or non-Federal systems/operations and, if so, the nature and extent of the sharing relationship

I urge NTIA to work with OMB to include IIC as well other approaches to facilitate spectrum sharing in design of new federal systems. In particular, traditional thinking in system designs before microwave and higher bands came into common use was the interference signals could not be discriminated against. suppressed or diminished in the potential interference victim's antenna system. But with the increased use of microwave and millimeterwave frequencies with small wavelengths discrimination on arrival direction is more feasible. MIMO antennas are coming into increased use in some types of mobile systems. MIMO is a special case of adaptive antennas originally developed for suppressing of hostile jamming signals in military applications. While today's MIMO systems focus on maximizing signal/noise ratio at the desired receivers, a variant of MIMO could also put some emphasis on suppressing undesired signals. In particular,

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[18] https://www.ntia.gov/sites/default/files/2023-11/10_2021_edition_rev_2023.pdf

[19] M. DiFrancisco *et al.,* Incumbent Informing Capability (IIC) for Time-Based Spectrum Sharing https://www.ntia.doc.gov/files/ntia/publications/fy2008_progress_report_spectrum_policy_initiative_and_cover_memo_29oct09.pdf
https://www.ntia.gov/sites/default/files/meetings/incentives_subcom_report_23jul10_revdclean_0.pdf

[20] https://www.ntia.gov/sites/default/files/publications/iic_for_time-based_spectrum_sharing_0.pdf

at upper frequencies where "Massive MIMO" is feasible due to small wavelengths and the resulting possibility of a large number of antenna elements, federal systems could consider tradeoffs between classic spectrum protection in exclusive bands versus using antenna technology to limit the impact of spectrum sharing. This should be considered for inclusion in the A-11 process.

For the special case of passive environmental satellites above 71 GHz, the provisions of WRC-19 Res. 731, originally proposed by the US at WRC-2000, explicitly provide that

> "the extent practicable, the burden of sharing among active and passive services should be equitably distributed among the services to which allocations are made"

Thus, NTIA should consider in the A-11 process for new federal passive satellites above 71 GHz the consideration of design features for proposed new satellite designs that facilitate spectrum sharing with NG terrestrial transmitters. For example, NTIA could require the proponents of unclassified passive satellites in these bands to enter a dialogue with NG fixed and mobile system designers to explore new design approaches, *e.g.* antenna patterns, for win/win sharing.

Addressing the Legislative Issue

While it would be desirable to have new legislation to update the above gaps in NTIA's authority to regulate G spectrum, much could be done by executive action. Virtually all G spectrum use is by Executive Branch agencies. While there is some federal spectrum use with NTIA assignments under 47 USC §§ 305,902 that are not with an Executive Branch agency, *e.g.*US Capitol Police, Architect of the Capitol and FCC's Enforcement Bureau and Laboratory, the vast majority of such assignments are with Executive Branch agencies which are under the President's leadership. It would appear that the President could direct in an executive order or presidential memorandum that all Executive branch agencies to obey NTIA's guidance/direction

on spectrum use beyond the literal "assignment" language of §305. However, such a direction from NTIA should be subject to the existing limitation of §902(b)(2)(A) that states that NTIA does not have "the authority to make final disposition of appeals from frequency assignments." Federal agencies generally do not feel "another agency" can direct them to do something absent specific statutory authority. I have heard this statement many times in meetings between NTIA staff and IRAC members. While agencies accept GSA's authority over their real property, OPM's authority over their staffing and personnel practices, and NSA's authority over encryption processes for classified material, they do not generally accept NTIA in the same way.

In order to make NTIA more credible to federal agencies, the procedures for appeals to the White House under §902(b)(2)(A) should be made clear to federal agencies, although not necessarily revealed to the public, and should be credible to the federal spectrum using agencies to obtain the "consent of the governed".

Brooking has published a detailed report on the 5G/radar altimeter controversy[21]. This may be the first public discussion ever of an issue that was the subject of a §902(b)(2)(A) review of NTIA's action. One does not have to be a supporter of FAA's viewpoint to see why the §902(b)(2)(A) review in this case was not credible. The report also appears to show that NTIA was ineffective to proposing credible alternatives to the affected parties for much of the period of this controversy and that FAA was also not engaging. **This type of interagency dysfunction must be addressing in the implementation of the National Spectrum Strategy.** Not only must NTIA be more proactive in identifying such difficult conflicts at an early stage, it must work with the agencies' concerned about the issue and FCC in a constructive way based on **both** the

[21] Dorothy Robyn, "Hard landing: Why the 5G rollout was so contentious and what we can learn from it" February 2, 2022 (https://www.brookings.edu/articles/hard-landing-why-the-5g-rollout-was-so-contentious-and-what-we-can-learn-from-it/)

overall national interests and solid technical analysis. The Brookings report implies that FAA leadership was uncomfortable with the technical analysis at NTIA and in the §902(b)(2)(A) review. For example, the report states

> Reports at the time suggested that the FAA did not trust NTIA to do the testing fairly or rigorously. Although such distrust was not merited, the FAA has a history of behaving as if no one outside the agency can understand its exacting safety standards.

The National Spectrum Strategy report mentions the Commerce Spectrum Management Advisory Committee (CSMAC) as one of

> "several advisory groups have been established to provide input to the Assistant Secretary of Commerce for Communications and Information on a broad range of spectrum issues"

Yet the reality is that CSMAC, and its FCC counterpart -- Technological Advisory Council, have played little to no role in resolving difficult G/NG conflicts sine they were created about 20 years ago. In order to minimize the costs of these groups they were chartered so most of their member were representatives of affected organizations and thus have conflicts of interests in most G/NG spectrum disputes. By contrast, both the Food and Drug Administration[22] and the Nuclear Regulatory Commission[23] use technical advisory committees of independent experts to provide technical advise on regulatory issues that is used by presidential appointees to make key policy decisions. These advisory committee pay their members – unlike TAC and CSMAC – and have members who do not have conflicts of interests, *e.g.* academics and retirees. Attachment 2 is a past recommendation from IEEE-USA that FCC and NTIA should consider creating a joint advisory committee of individuals with security clearances but without conflicts, as FDA and NRC does, to address policy options for resolving difficult G/NG spectrum issues. Such advice

[22]

[23] https://www.nrc.gov/about-nrc/regulatory/advisory/acrs.html

could be used by NTIA and FCC leaders in resolving difficulty spectrum issues including §902(b)(2)(A) reviews of NTIA actions. It would also make the results of such reviews more acceptable to all parties and restore comity.

It should also be noted that Congress directed DoD to have NASEM review the long standing Ligado/GPS controversy to resolve disagreements and that this NASEM review was acceptable to most involved.[24] While FCC and NTIA have rarely asked NASEM for advice on specific or general issues, this is a reason why NASEM was chartered by Congress in the 19th century and is more common practice in other agencies with technical jurisdiction -- making FCC and NTIA outliers from best practices in public policy in technical areas.

There are also several provisions of the pending *"NTIA Reauthorization Act of 2023",* HR 4510 that would "facilitate the consent of the governed" by making NTIA interaction with FCC that affect G spectrum more transparent to IRAC members and improve mutual trust. While most of the provisions in the pending legislation need enactment to be implemented, it appears to the author – admittedly not a lawyer – some helpful provisions in Title II of HR 4510 could be implemented by executive action. These are listed in Attachment 3.

The "Endrun" Problem

The ineffectiveness of the current arrangements for managing G spectrum is typified by a series of "endruns" by IRAC members over the years that are attempts to bypass NTIA's authority. While "endruns" do **not** include actions seeking a review of NTIA's §305 "assignments" that are explicitly authorized pursuant to the provisions of §902(b)(2)(A).

These endruns include

- 1987 FAA request to Congress for authority to regulate "interference to air navigation facilities" that was adopted in PL 100-223 and is now codified in 49 USC §44718. This

[24] https://www.nationalacademies.org/our-work/review-of-fcc-order-20-48-authorizing-operation-of-a-terrestrial-radio-network-near-the-gps-frequency-bands

includes no role at all for NTIA in such considerations and has been a long term conflict between FCC and FAA.
- DoD request to Congress for GPS/Ligado NASEM study legislation
- Expiration of FCC auction authority apparently at the request of DoD due to concerns over one particular reallocation that resulted in an auction.
- C band radar altimeters/5G controversy and apparent FAA stonewalling study of altimeter receivers and options for mitigating interference
- 20+ years of NASA opposition to ITU-R studies on US proposals to WRC-2000 that codified ITU in Resolution 731[25], on sharing studies for passive satellite bands in 71-275 GHz

In a perfect world NTIA would be able to prevent these endruns in the future by being stronger like GSA, OPM, and NSA are in their regulation of other agencies. But that is unlikely without new legislation as is complicated by NTIA's present position in DOC. But improving the mutual dialogue between spectrum using agencies and NTIA thought the new Interagency Spectrum Advisory Council should be very useful. The highlevel agency member of the Council must feel that their views are heard and that a fair and transparent system is used to resolve technical disputes. The Brookings review of the 5G/radar altimeter dispute shows why FAA leadership did trust the result of the §902(b)(2)(A) review of NTIA and FCC's decision. The type of independent advisory committee proposed by IEEE-USA would increase confident on the objective issues of whether there is interference and technical options to decrease such interference. The subjective issues such as the importance of interference and the benefits of the other spectrum use would be left to senior policymakers including those who are specifically enabled to participate in the §902(b)(2)(A) review. While such improvements will not eliminate all endruns, note the FBI is now publicly protesting GSA's selection of a new site for their headquarters, it should significantly reduce the endruns and bring more order and timely resolution to G/NG spectrum disputes. This in turn should facilitate the private capital formation that is necessary for most telecom R&D and for rollout of new telecom technology.

[25] https://www.itu.int/dms_pub/itu-r/oth/0C/0A/R0C0A00000F00149PDFE.pdf

NTIA's Roles as a Department of Commerce Entity

NTIA has been part of DOC since it was created in 1978. The 1992 National Telecommunications and Information Administration Organization Act[26] codified this organizational relationship. Transparency and the US manufacturing sector are two long term goals of the Commerce Department as whole.

In the transparency area, NTIA is granted by FCC an exemption to the normal *ex parte* rules[27] that apply to all outside entities, whether governmental or not. Under § 1.1204(a)(5) of the FCC's Rules[28], an agency such as NTIA that "shares jurisdiction" does not have to file *ex parte notices*

> "provided that, any new factual information obtained through such a presentation that is relied on by the Commission in its decision-making process will, if not otherwise submitted for the record, be disclosed by the Commission no later than at the time of the release of the Commission's decision"

The First Report and Order of FCC of Docket 18-21[29], "Spectrum Horizons" addressed spectrum above 100 GHz, virtually all of which is G/NG shared spectrum subject to the FCC/NTIA MOU. NTIA and IRAC are mentioned in this FCC decisions in several sections. Yet the FCC Docket file, ECFS, for this proceeding contains no filings from NTIA at all, an apparent violation of the provisions of § 1.1204(a)(5). Since it is generally not clear which proceedings have NTIA contact with FCC subject to § 1.1204(a)(5) filings "no later than at the time of the

[26] PL 102-538, Oct. 27, 1992, 106 STAT. 3533
[27] Federal agencies involved in informal rulemaking document and disclose *ex parte* contact during "such rulemakings. FCC's specific approach of requiring the outsider to make a public filing is unusual among such agencies but has been upheld in agency reviews of it. R&O&FNPRM, FCC Docket 10-43, Feb. 2011, (https://docs.fcc.gov/public/attachments/FCC-11-11A1.pdf)
See E. L. Sferra-Bonistalli, *Ex Parte* Communications in Informal Rulemaking Final Report, Administrative Conference of the US, May 1, 2014 (https://www.acus.gov/sites/default/files/documents/2014-4%20Report.pdf)
[28] 47 CFR § 1.1204(a)(5)
[29] FCC, 1stR&O, Docket 18-21, March 2019 (https://docs.fcc.gov/public/attachments/FCC-19-19A1.pdf)

release of the Commission's decision", it is not possible for an outsider to check NTIA's compliance with this filing requirement. However, a check of FCC's ECFS comment filing system indicates no such filings on spectrum issues in the past several years. It is suggested that NTIA review its compliance with § 1.1204(a)(5) and if it has not been thorough then takes steps to improve is compliance in a timely way.

I also suggest that NTIA review transparency aspects of a recurring issue in which private parties trying to influence an FCC proceeding by exploiting NTIA ability to raise a new issue with FCC without the normal public *ex parte* disclosure officials. A private party can do so by discussing with NTIA a possible interference concern that might impact a federal spectrum user. The private party thus seeks to get an unfair advantage in the proceeding in the hope that NTIA be concerned about the inference allegation and urge FCC address the concern by limiting the proposed spectrum use. This resulting NTIA contact with FCC will be off the public record under the literal terms of § 1.1204(a)(5) "until the release of the Commission's decision". Thus, it will be difficult to impossible to rebut the allegation concerns in a timely way. This gives a real advantage to the private party that contacted NTIA and appears to be antithetical to DOC transparency goals as well as the goals of the *ex parte* disclosures. I have addressed this issue in comments to FCC and stated

> "The solution to this problem is to urge NTIA to file in the public record any outside contact with non-federal entities presenting information they want NTIA to forward to FCC in an ongoing rulemaking subject to *ex parte* procedures. (Entities that are contractors performing spectrum management studies for NTIA or agencies using spectrum under NTIA assignments should continue to be exempt from such procedures.) [30]

[30] Comments of Marcus Spectrum Solutions LLC, FCC Docket 10-43, March 2010 at Section V (https://www.fcc.gov/ecfs/document/6015544201/1)

I urge NTIA to review this issue with FCC and take steps to assure transparency in its interactions with FCC that result from concerns of private entities. NTIS's role is to regulate federal spectrum, not to do favors for private entities that want on communicate with FCC on pending decisions off the public record.

Another possible conflict with Department of Commerce (DOC) goals is in the area of a promising spectrum technology used for noncommunications uses in manufacturing. The DOC website states

> The Department of Commerce is focused on continuing to bring manufacturing into the 21st century across the United States through innovative new techniques, a next-gen workforce and a driven economy. Through Manufacturing USA, Commerce is able to reach new heights in sector innovation and funding.[31]

Rarely do DOC goals conflict with goals of IRAC members. But the case of a technology known as "Time Domain Spectroscopy"[32] there is a basic conflict since this technology that can improve several types of manufacturing operations by providing real time nondestructive quality control by using contiguous bandwidths above 100 GHz that are tens or hundreds of GHz wide. NASA and NOAA operate passive environmental satellites in this region of the spectrum and have consistently opposed transparent regulation of this technology. While I believe that win/win policies can be developed that **both** allow use of this technology under transparent rules (as CEPT has already done)[33], NASA and NOAA appear to view this technology as only a threat that has only a downside with respect to the agencies spectrum-based systems. Thus, absent

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[31] https://www.commerce.gov/issues/manufacturing

[32] https://en.wikipedia.org/wiki/Terahertz_time-domain_spectroscopy
https://lunainc.com/capability/thickness
In Europe this technology is called "Radiodetermination systems for industry automation in shielded environments (RDI-S)"

[33] CEPT/ECC, Technical characteristics, exemption from individual licensing and free circulation and use of specific radiodetermination applications in the frequency range 116-260 GHz, ECC Decision (22)03, 18 November 2022 (https://docdb.cept.org/download/4217)

effective NTIA leadership on new spectrum uses and spectrum sharing, they have every incentive to oppose this technology or even its consideration using every tools at their disposal and their past actions confirm this.

For example, in the drafting of a recent US contribution to ITU-R WP 5B[34] by USWP5B, NASA and NOAA consistently opposed this document with apparently no guidance from NTIA on either US or DOC priorities on this issue. While this document ultimately was sent to ITU-R, this was only after a long drawn-out process when finally the Department of State in consultation with FCC and NTIA overruled the NASA objection. I suggest that NTIA review this incident and see whether earlier guidance to NASA and NOAA and earlier NTIA mediation of the terms of the US input might have been in the interest of all involved.

IRAC's Legal Status

Currently the only explicit statutory references to IRAC are these two provisions:

> **47 USC §903**: Spectrum management activities
> (a) Revision of regulations
>
> Within 180 days after October 27, 1992, the Secretary of Commerce and the NTIA shall amend the Department of Commerce spectrum management document entitled "Manual of Regulations and Procedures for Federal Radio Frequency Management" to improve Federal spectrum management activities and shall publish in the Federal Register any changes in the regulations in such document.
> (b) Requirements for revisions
> The amendments required by subsection (a) shall—
> (1) provide for a period at the beginning of each meeting of the Interdepartmental Radio Advisory Committee *(sic)* to be open to the public to make presentations and receive advice, and provide the public with other meaningful opportunities to make presentations and receive advice;
>
> **47 USC §904(b):** To the extent the Assistant Secretary deems it necessary to continue the Interdepartmental Radio Advisory Committee *(sic)*, such Committee shall serve as an advisory committee to the Assistant Secretary and the NTIA…

[34] US Input to ITU-R WP5B, "Characteristics and Sharing Criteria of Terrestrial Terahertz Spectroscopy/ Radiodetermination Systems for Industry Automation in Shielded Environments (RDI-S) in the band 71-275 GHz", June 29, 2023 (https://www.itu.int/md/R19-WP5B.AR-C-0494/en) (ITU TIES account needed for access)

While the provisions of §904(b) shows Congress recognizes the present existence of IRAC, it is not a ringing endorsement or a mandate of either its role or its current procedures. It is striking that the Presidential Memorandum[35] establishes the Interagency Spectrum Advisory Council to replace the prior Plans and Policy Steering Group, but does not make *any* changes to IRAC. When NTIA was created in 1978 the IRAC charter was not updated at all and the December 10, 1964 charter continues in force and *is not even publicly available*. Attachment I is a copy of this document that I obtained by a FOIA request.

I urge NTIA to review the current charter, consider updating it, and make the resulting charter readily available to the public. In particular, I feel that it should address the issue of whether IRAC representatives prime loyalty is to their agency or the "interest of the United States as a whole". At present this is addressed in the IRAC Bylaws which states

> "The basic role of representatives appointed to serve on the IRAC is to function, when in Committee, in the interest of the United States as a whole."[36]

I suggest that NTIA either should delete this section or clarify, in consultation with IRAC members, what it actually means . I vividly remember once raising the issue of the "public interest" at an IRAC *ad hoc* subcommittee meeting and was lectured that all the members of the subcommittee were federal employees acting on behalf of their agencies and therefore *anything* they requested was "in the public interest" and that private sector parties sought to use spectrum only to "make money". I hope NTIA can develop a more nuanced interpretation of the roles of representatives of IRAC members and its goals.

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[35] Memorandum on Modernizing United States Spectrum Policy and Establishing a National Spectrum Strategy November 13, 2023 (https://www.whitehouse.gov/briefing-room/presidential-actions/2023/11/13/memorandum-on-modernizing-united-states-spectrum-policy-and-establishing-a-national-spectrum-strategy/)

[36] NTIA, *Manual of Regulations for Federal Radiofrequency Spectrum Management*, (January 2023 Revision), §1.3.2, Art. 2, Sec.3 (https://www.ntia.gov/sites/default/files/2023-11/1_2021_edition_rev_2023.pdf)

Conclusions

The above discuss addresses several concerns about past practices at NTIA and IRAC that have developed over the past decades. New technologies and new uses of radio spectrum challenges structures and procedures dating back to the early dates of radio technology. It is important that these issues be addressed objectively although reasonable people could disagree on specific issues. Since my days at FCC, I have kept on my office wall a framed version of this poem by the Dutch poet Piet Hein:

"Problems worthy of attack
prove their worth
by fighting back."

Do not fear addressing problems that have been ignored for decades.

/S/

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January 2, 2024

Attachment I – Present December 10, 1964 IRAC Charter

FOR INFORMATION

Doc. 8832/1-2.11/2.2.3

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF EMERGENCY PLANNING
OFFICE OF THE DIRECTOR OF TELECOMMUNICATIONS MANAGEMENT
Washington, D. C. 20504

NOTICE TO ALL FEDERAL USERS OF TELECOMMUNICATIONS

SUBJECT: Interdepartment Radio Advisory Committee

1. Purpose. To prescribe the status, mission and functions of the Interdepartment Radio Advisory Committee.

2. Authority. This notice is issued pursuant to Executive Order 10995 of February 16, 1962, as amended, with particular reference to Sections 2, 3, 5, 8 and 9 thereof.

3. Status. The Interdepartment Radio Advisory Committee (IRAC), which was organized by mutual agreement of the Government departments concerned on June 1, 1922, and reconstituted by the Telecommunications Advisor to the President on October 6, 1952, shall be continued. It shall report to the Director of Telecommunications Management.

4. Composition. It consists of a representative appointed by each of the following departments and agencies:

Agriculture	Justice
Air Force	National Aeronautics & Space Administration
Army	Navy
Commerce	State
Federal Aviation Agency	Treasury
General Services Administration	United States Information Agency
Interior	

together with representatives of such other agencies as the DTM may hereafter designate.

The basic role of persons appointed to serve on the IRAC is to function, when in Committee, in the interest of the United States as a whole, and not in the interest of any particular department or agency.

Liaison between the IRAC and the Federal Communications Commission (FCC) is effected by a representative appointed by the Commission to serve in that capacity.

5. Mission. The mission of the IRAC shall be to formulate and recommend to the DTM objectives, policies, plans and actions as appropriate in connection with the management and usage of the radio spectrum in the national interest by the departments and agencies of the U. S. Government.

6. Functions. The basic functions of the IRAC in the discharge of that mission are as follows:

a) Recommend, in consultation with the FCC, national objectives in the allocation and use of the radio frequency spectrum, together with the policies designed to achieve those objectives.

b) Recommend policies, criteria, technical standards, regulations, justifications and procedures for the acquisition and use of frequencies by U. S. Government agencies.

c) Execute such policies, plans and actions pertaining to the management and usage of the radio spectrum as the DTM may from time to time direct.

d) Develop U. S. Government radio frequency requirements.

e) Subject to the approval of the DTM, effect the assignment of frequencies to the radio stations and classes of stations of the U. S. Government, and modify or revoke such assignments as appropriate.

f) Make technical recommendations with respect to the frequencies proposed for use by foreign governments in the fixed service at the United States seat of Government.

g) Maintain, in collaboration with the FCC, continuing review of the Table of Frequency Allocations to ensure that the division of the radio spectrum as between Government and non-Government users serves the national interest; carry on joint planning for use of the spectrum on a short-term and long-term basis; recommend, in the light of national security and foreign relations, allocations for Government use; and maintain the Government Table of Frequency Allocations.

h) Maintain, in collaboration with the FCC, plans for use of the radio spectrum in a war emergency.

i) Maintain under continuing review the actual use of assigned frequencies by Government agencies to determine whether they are still required and are being used effectively for the purpose for which they were obtained.

j) Supervise the notification to the International Telecommunication Union/International Frequency Registration Board (ITU/IFRB) of Government frequency assignments, and supply the IFRB data pertaining thereto as appropriate.

k) Coordinate with the Department of Transport, Canada, the use of frequencies in the prescribed US-Canada border zones, in those cases where the IRAC is designated as the Coordination Agency in the Agreement between the United States and Canada for the Coordination and Use of Radio Frequencies above 30 Mc/s.

l) With respect to radio spectrum management, assist the DTM in the formulation of advice to the Department of State, in the discharge of its functions in the field of international telecommunication policies, positions and negotiations by developing, in consultation with the FCC national positions thereon for international projection.

m) Assist the DTM in carrying out the international treaty obligations of the United States within the field of activity of the IRAC.

7. Staff Support. The officers of the IRAC and its subcommittees, together with its secretariat, will be supplied by the OEP/DTM.

8. Internal Mechanisms. The IRAC may establish such bylaws and procedures as it considers necessary to discharge its functions.

J. D. O'Connell
Director of Telecommunications Management

Date: December 10, 1964

OEP 56287

Attachment 2: 2010 IEEE-USA Recommendation on a new advisory committee for FCC and NTIA

> **The FCC and NTIA should supplement the FCC's existing Technological Advisory Council (TAC) and NTIA's Commerce Spectrum Management Advisory Committee (CSMAC), which consist mainly of representatives of major communications firms, with a new advisory committee that serves both agencies and focuses on independent reviews of options for resolving spectrum conflicts and identifying outdated policies. The new group should be modeled on the EPA Science Advisory Board and the NRC Advisory Committee on Reactor Safeguards. Members should have the necessary security clearances to deal with issues involving classified federal government spectrum users.**

Both the FCC's TAC and NTIA's CSMAC have been filled with members who are, in most cases, representatives of affected parties. While this representation is beneficial in many cases -- in reviewing what affected parties want and how they might be impacted by possible decisions -- it does not necessarily provide the agencies with all the options possible with today's technologies. The FCC has never asked the TAC to recommend or evaluate options on pending docketed proceedings. On the NTIA side, the CSMAC charter has no provisions for classified deliberations, indicating that NTIA is not using CSMAC for reviewing many key pending government/federal spectrum policy matters.

The FCC and NTIA should also supplement their existing committees with a new advisory committee, patterned on the prestigious committees that serve Nuclear Regulatory Commission (NRC) and Environmental Protection Agency (EPA), consisting of distinguished members without immediate conflicts of interest (e.g., academics and retirees who have agreed to limit their consulting activities in exchange for payment as special government employees). A common committee that advises both agencies would be a cost-effective way to make sure both are presented with objectively evaluated technology policy options. The FCC commissioners and the NTIA administrator can then combine this input with more subjective factors in making policy decisions in the national interest.

Attachment 3: Provisions of HR 4510 that appear to promote FCC/NTIA/IRAC member mutual trust/cooperation and *might* possibly be implemented without new legislation

"SEC. 107. IMPROVING SPECTRUM MANAGEMENT.

"(a) FEDERAL COORDINATION PROCEDURES.—

"(1) NOTICE.—With respect to each spectrum action, not later than the end of the period for submitting comments to the Commission in the proceeding relating to the spectrum action, the Under Secretary shall file in the public record with respect to the proceeding information (redacted as necessary if the information is protected from disclosure for a reason described in paragraph (3)) regarding—

"(A) when the Commission provided notice to the Under Secretary regarding the spectrum action, as required under the Memorandum;

"(B) the Federal entities that may be impacted by the spectrum action;

"(C) when the Under Secretary provided notice to the Federal entities described in subparagraph (B) regarding the spectrum action;

"(D) a summary of any general technical or procedural concerns raised by Federal entities to the Under Secretary regarding the spectrum action; and

"(E) any policy concerns of the Under Secretary regarding the spectrum action.

"(2) FINAL RULE.—If the Commission promulgates a final rule under section 553 of title 5, United States Code, involving a spectrum action, the Commission shall prepare, make available to the public, and publish in the Federal Register along with the final rule an interagency coordination summary that describes—

"(A) when the Commission provided notice to the Under Secretary regarding the spectrum action, as required under the Memorandum;

"(B) whether the Under Secretary raised technical, procedural, or policy concerns regarding the spectrum action; and

"(C) how any concerns described in subparagraph (B) were resolved.

"(3) RULE OF CONSTRUCTION.—Nothing in this subsection may be construed to require the disclosure of classified information, or other information reflecting technical, procedural, or policy concerns that is exempt from disclosure under section 552 of title 5, United States Code (commonly known as the 'Freedom of Information Act').

"(4) FCC CONSIDERATION.—The Commission may not consider any technical, procedural, or policy concerns of a Federal entity regarding a spectrum action unless such concerns are filed by the Under Secretary on behalf of the Federal entity in the public record with respect to the proceeding of the Commission relating to the spectrum action.

"(4) PUBLIC CONTACT.—

"(A) IN GENERAL.—The head of each Federal entity described in paragraph (2) shall list, on the website of the Federal entity, the name and contact information of the representative of the Federal entity to the PPSG, as appointed under such paragraph.

"(B) NTIA RESPONSIBILITY.—The Under Secretary shall publish on the public website of the NTIA a complete list of the representatives to the PPSG appointed under paragraph (2).

SEC. 203. SPECTRUM MANAGEMENT IMPROVEMENTS.

(a) PROTOTYPING.—Consistent with subparagraphs (F), (L), (P), and (U) of section 103(b)(2) of the National Telecommunications and Information Administration Organization Act (47 U.S.C. 902(b)(2)), the Under Secretary, in coordination with the Commission, shall develop, establish, prototype, and support the implementation of common models, common methodologies, and common inputs to inform electromagnetic spectrum management decisions with respect to frequencies assigned on a primary or co-primary basis to 1 or more Federal entities, such as—

(1) technologies and techniques to control radio frequency emissions and interference;

(2) advanced antenna arrays, and artificial intelligence systems and technologies capable of operating advanced antenna arrays, including multiple-input, multiple-output antennas, beam forming and steering technology, antenna nulling technology, and conformal arrays;

(3) network sensing and monitoring technologies;

(4) advanced receivers that incorporate new technologies supporting new waveforms and multiple bands;

(5) dynamic spectrum access technologies across wireless systems and frequencies, including local-to-the-radio and cognitive multidomain access;

(6) novel spectrum access technologies;

(7) artificial intelligence systems to enable dynamic spectrum access, Internet of Things networks, and other advanced communications technologies; and

(8) optical and quantum communications technologies.

(b) SPECTRUM MANAGEMENT AND ADVANCED COMMUNICATIONS TECHNOLOGIES.—Section 104 of the National Telecommunications and Information Administration Organization Act (47 U.S.C. 903) is amended by adding at the end the following:

"(f) IDENTIFICATION AND IMPLEMENTATION OF SPECTRUM MANAGEMENT TECHNOLOGIES.—The Under Secretary shall identify and implement technologies that promote, with respect to frequencies assigned on a primary or co-primary basis to 1 or more Federal entities—

"(1) dynamic spectrum access;

"(2) network sensing and monitoring; and

"(3) optical and quantum communications.

"(g) PROTOTYPING OF ADVANCED COMMUNICATIONS TECHNOLOGIES.—The Under Secretary shall, with respect to frequencies assigned on a primary or co-primary basis to 1 or more Federal entities—

"(1) encourage the development of, and broad participation in, a skilled workforce to conduct prototyping of advanced communications technologies; and

"(2) support partnerships among institutions to develop a skilled workforce to conduct prototyping of advanced communications technologies.".

SEC. 207. VOLUNTARY CRITERIA, STANDARDS, RATINGS, AND OTHER MEASURES FOR CERTAIN RADIO RECEIVERS.

(a) ESTABLISHMENT OF WORKING GROUP.—

(1) IN GENERAL.—Not later than 90 days after the date of the enactment of this Act, the Under Secretary shall convene a working group to assist the Under Secretary in developing, and periodically updating, voluntary criteria, standards, ratings, and other measures with respect to radio receivers operating in Federal systems in spectrum bands allocated for exclusive Federal use.

(2) PURPOSE.—The purpose of the voluntary criteria, standards, ratings, and other measures developed, and periodically updated, by the Under Secretary under this section, with the assistance of the working group, shall be to provide guidance on the design, manufacture, and sale of radio receivers designed (in whole or in part) to operate in Federal systems in spectrum bands allocated for exclusive Federal use—

(A) with respect to the incorporation of appropriate measures to mitigate, or enhance resiliency to, potential harmful interference; and

(B) with the goal of ensuring that the reasonable current and future use of cochannel and non-cochannel spectrum, including use by non-Federal systems of spectrum designated by the Commission for commercial operations, will not result in the operation of such receivers being seriously degraded or obstructed, including such operation being repeatedly interrupted.

Attachment 4: Paper from 2011 NTIA ISART Conference on Sharing

https://its.ntia.gov/umbraco/surface/download/publication?reportNumber=ISART11paper_Marcus_final-1.pdf

Proceedings of the 2011 International Symposium on Advanced Radio Technologies, NTIA Special Publication SP-12-485, March 2012

Thoughts on Radar/Communications Spectrum Sharing

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***Abstract*—This paper reviews a new approach to radar/communications spectrum sharing that is based upon parallel design of cochannel radar and communications systems with cost sharing between the two communities of users. Since the majority of the mobile wireless growth is not in symmetric voice connectivity but in asymmetric packetized information, the traditional full time access pair spectrum is not needed for the growth. Sharing with radar can lead to communications capacity to meet the needs of growth.**

Keywords-radar, spectrum policy, spectrum sharing

I. INTRODUCTION

Wireless communications is a key infrastructure in today's economies and societies. Spectrum is a key building for such wireless systems and is a key component for governmental[1] systems that are essential to security. Classically these two uses of spectrum have been mostly viewed as a "zero sum game", that is spectrum could be either used for nongovernmental communication uses or for governmental applications. There is sharing, but it generally is on a regional basis or a frequency by frequency basis, so the two classes of users are not on the same frequency at the same location.

But the need for spectrum is too great now to let this traditional viewpoint continue unchallenged. Economic security is also now recognized as a key aspect of national security.[2] Finally, the national security budget is now in the 3-5% of GDP range and any increases in national security spending will have to be tied to GDP growth under the current and foreseeable budgeting paradigms. Thus the national security community should consider with "what's good for the GDP, is good for national security".

The UK government has looked at the general spectrum problem and its counterpart of the US Executive Branch has declared,

> Spectrum is a valuable resource that enables growth and innovation by the private sector. Spectrum is also essential to the running of public services including defence, emergency services and transport. However, as part of the Government's drive to manage more effectively the nation's assets, we are committed to releasing surplus public sector spectrum to more productive private sector use.[3]

In the US, radar has been classically a major use of spectrum by federal government agencies. While there has been some very limited sharing on a geographical basis, the general view has been that such spectrum could not be shared with communications systems since the nature of the uses were so different. But new advances in communications technology and in the evolving nature of wireless communications mean that we should reexamine sharing options.

II. U-NII DFS TRANSPARENCY URGENTLY NEEDED

On November 12, 2003 FCC approved the Report and Order in Docket 03-122[4] authorizing unlicensed device/radar

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[1] In this paper, I am using "government" in its generic usage, not the US spectrum management usage where it refers to federal government spectrum use.

[2] "To achieve the world we seek, the United States must apply our strategic approach in pursuit of four enduring national interests:

- Security: The security of the United States, its citizens, and U.S. allies and partners.
- Prosperity: A strong, innovative, and growing U.S. economy in an open international economic system that promotes opportunity and prosperity.
- Values: Respect for universal values at home and around the world.
- International Order: An international order advanced by U.S. leadership that promotes peace, security, and opportunity through stronger cooperation to meet global challenges." (emphasis added)

White House, National Security Strategy, May 2010, p. 17 (http://www.whitehouse.gov/sites/default/files/rss_viewer/national_security_strategy.pdf)

[3] "Enabling UK growth – Releasing public spectrum:Making 500 MHz of spectrum available by 2020", March 2011 http://www.culture.gov.uk/images/publications/Spectrum_Release.pdf

[4] http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-03-287A1.pdf

sharing in the 5.25-5.35 GHz and 5.470-5.725 GHz bands. An earlier January 31, 2003 NTIA announcement stated

> The NTIA, FCC, NASA and Department of Defense (DoD), working closely with industry in detailed technical meetings, have agreed to modify the required Dynamic Frequency Selection (a listen-before-transmit mechanism) detection threshold characteristics contained in the U.S. proposal for WRC-03 Agenda Item 1.5.[5]

Since the adoption of these rules it has become clear that there have been recurring interference incidences, particularly involving the FAA's Terminal Doppler Weather Radar (TDWR) system. There appear to be three possible causes of this interference:

U-NII devices using the radar bands lack the dynamic frequency selection (DFS) capability required by 47 C.F.R. 15.407 either because it was not included in the design or because it was disabled through a software change after the design was approved.

U-NII devices with DFS capability but due to testing ambiguity they were not capable of the performance expected by those who drafted the agreement announced by NTIA on 1/31/03

U-NII devices met the capabilities expected in the agreement, but these DFS features were not adequate to prevent interference in specific circumstances

It is clear from both a November 2010 NTIA/ITS report[6] and from FCC enforcement cases that are on the public record that some cases[7] fall in the first category. It appears that some also fall in the third category where the standard adopted by FCC after consensus with industry and NTIA was not adequate to prevent interference. This is the clear conclusion of the July 27, 2010 memo from FCC's Office of Engineering and Technology and Enforcement Bureau [8] to "Enforcement Manufacturers and Operators of Unlicensed 5 GHz Outdoor Network Equipment". The memo states,

> "We have found that the interference at each location has generally been caused by a few fixed wireless transmitters used by wireless internet service providers (WISPs) and operating outdoors in the vicinity of airports at high elevations that are line-of-sight to the TDWR installations (5 GHz outdoor network equipment). In most instances, the interference is caused by operations in the same frequency band as TDWRs, but there are some instances where the interference is caused by adjacent band emissions."

The existence of cases in the third category is also seen in an NTIA presentation at last year's ISART.[9] However in both the case of the first category and the third category cases, these is no explanation on the public record as to the root causes of these problems. In order to develop future cognitive radio systems that share with radars on a noninterference basis, we need to learn from problems such as this one. As George Santaya wrote, "Those who cannot learn from history are doomed to repeat it."

The cognitive radio research community learned about the TDWR interference through cryptic FCC and NTIA statements, but there has been no technical information released to date on the specifics problems that arise from properly working DFS systems in high antennas near TDWR systems. The power budget modeling that was used in making the January 2003 agreement appears to have been wrong in the case of TDWR, yet there is no quantitative information on what we have learned on how to model these situations better. While some of the military radars involved in the 2003 analysis are classified, the TDWR appears to be an unclassified system so it is hard to believe that there is a valid national security justification for with holding information on the nature of the interference and why operational experience differs from the models used in 2003. While there is not a need to identify personal or organizational responsibility here, there is a need to understand the technical issues involved.

There have also been hints that some of the interference is due to first category – DFS systems that were disabled after they were tested and approved. In particular the AT&T/San Juan case[10] seems to be in this category. The original software defined radio (SDR) rules adopted in Docket 00-47 in September 2001 were relaxed in Docket 03-108 at the request of industry. The original rule[11] required protection against

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[5] http://www.ntia.doc.gov/ntiahome/press/2003/5ghzagreement.htm

[6] NTIA/ITS, Case Study: Investigation of Interference into 5 GHz Weather Radars from Unlicensed National Information Infrastructure Devices, Part I; NTIA Report TR-11-473, November 2010 (http://www.its.bldrdoc.gov/pub/ntia-rpt/11-473/)

[7] http://www.fcc.gov/Daily_Releases/Daily_Business/2011/db0217/DA-11-306A1.pdf

[8] http://www.wispa.org/wp-content/uploads/2010/05/FCC-Memorandum-on-UNII-Device-Operartion-July-27-2010-1.pdf (sic)

[9] Frank Sanders (NTIA), "5 GHz DFS Technology Devvelopment and Deployment: Challenges Met and lessons Learned", Presentation at ISART 2010(July 2010) http://www.its.bldrdoc.gov/isart/art10/slides_and_videos10/DFS%20development%20and%20lessons%20learned%20FHS.pdf

[10] http://www.marcus-spectrum.com/Blog/files/d7110e2482463dd2de998df926ceea1f-191.html

[11] "2.932(e) Manufacturers must take steps to ensure that only software that has been approved with a software defined radio can be loaded into such a radio. The software must not allow the user to operate the transmitter with frequencies, output power, modulation types or other parameters outside of those that were approved. Manufacturers may use authentication codes or any other means to meet these requirements, and

tampering, such as authentication codes, for *all* equipment where the software can change the unit's parameters. The current rules only require such protection if the unit is *marketed* as being changeable by the end user. FCC and NTIA should be more forthcoming as to whether some of the TDWR interference encountered was caused by software disabling of DFS function in units that are not subject to security requirements and testing in the former 2.932(e) as a result on the Docket 03-108 changes.

The author urges FCC and NTIA to use the occasion of ISART 2011 and the ensuing dialogue on communications/radar sharing to make a full technical disclosure on the nature and causes of the TDWR interference.

III. Design of New Radar and Communications Systems with Sharing as an Objective

The basic problem that the 5 GHz DFS system has is that the various radar systems it has to share with on a noninterference basis were not designed with sharing in mind. (The fact that the sponsors of these radar systems are basically the "judge and jury" for determining the risk of interference in any sharing scheme under today's spectrum policy arrangements also complicates things.) I explored this general issue in my 2007[12] and 2010[13] DySPAN papers.

The basic point on cooperative sharing vis-à-vis passive sensing is shown below:

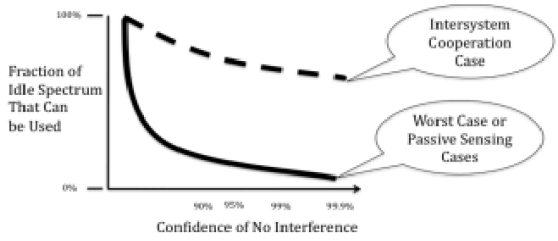

Figure 1. Postulated relationship between spectrum use and interference

In a cognitive radio or dynamic spectrum access system that depends solely on passive sensing of primary, e.g. radar, signal the only way to get a high confidence of noninterference is to use a small fraction of the idle spectrum. The probability of detection must be set so high that the probability of false alarm is very high – a false alarm meaning here that idle spectrum can not be used.

Designs with intersystem cooperation can potentially achieve much higher spectrum use with the same interference risk. This is because cooperative systems can effectively emulate nonrealizable systems, that it, systems that can predict the future based on other than past observations. The best DFS system can only make statements on past observations – if the primary system is about to turn on or change parameters it can not know that until after it happens. Allowing for such events requires more conservative sharing parameters as are seen in the 5 GHz DFS case.

But cooperative systems can share information about present and future transmissions and hence have more effective spectrum sharing while maintaining a low interference risk.

A. Changes in Wireless Spectrum Use Today

Before we get into cooperative radar/communications system design it is necessary to make an observation on trends in today's wireless spectrum use. Traditionally the wireless industry sought paired spectrum for full duplex operations. While the national Broadband Plan [14] does not state so explicitly, the 500 MHz of additional spectrum sought in Recommendation 5.8 is presumably full duplex spectrum. It is also unstated but presumed that this spectrum is full time availability spectrum - that is that it is available 24/7 **and** 1000 ms/1s.

When wireless use was predominantly 2 way voice these presumptions made sense. However, this is not the growth area in today's spectrum use. Total voice minutes may be actually declining. Today's growth in wireless communications is in packetized information and is generally asymmetric in its uplink/downlink ratio. Wireless spectrum users do not actually want spectrum, they want communications capacity![15]

Having asked for symmetric spectrum for 3G applications the wireless industry may be regretting that it got what it asked for. While carriers are secretive about the specific asymmetry of their present traffic load, it is clear that downlink traffic dominates and will continue to dominate. Furthermore, most of this packetized asymmetric traffic can be handled with more time delay flexibility than voice or 2 way video. While some user may want to pay a premium for very low latency communications, there may well be a market for latencies in the 0.5s – 2s range. Note also that the services offered by Sirius/XM have a latency resulting from time diversity used to control momentary path outages and few users have ever noticed it. Finally today's packet switching technology allows the design of systems that reroute packets on a real time basis as communications channels become available or unavailable.

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must describe the methods in their application for equipment authorization."(Rules adopted in Docket 00-47)

[12] http://www.marcus-spectrum.com/resources/Marcus-DySPAN07a.pdf

[13] http://www.marcus-spectrum.com/documents/DySPAN10.pdf

[14] http://www.broadband.gov/download-plan/

[15] Note that radar users, by contrast, often *can* convert their requirements into bandwidth since radar performance in many cases is directly related to bandwidth since bandwidth is inversely proportional to ambiguity function width in the time domain.

B. Radar/Communications *Joint* Design

A key aspect of the development of the B-2 stealth bomber was that for the first time aeronautical engineers and electromagnetic engineers worked on an integrated team to design an innovative aircraft that could both fly well to perform its mission and have a negligible radar cross section. Similarly, there are tremendous benefits possible for joint design of communications and radar systems to share the same spectrum. The *ex post facto* approach used for 5 GHz DFS is doomed to have limited utilization of available spectrum.

Most noncombat radars rotate, most with mechanical rotation, a few with electronic rotation. Thus at a given moment the RF power is focused in one azimuth and that azimuth is changing with time. Similarly the radar receiver is focusing on one azimuth also. The antenna pattern governs how well focused the transmitter and receiver are and finite size antennas must inevitably have sidelobes and backlobes. But antenna design techniques exist to reduce such sidelobes and backlobes although designers of radars not subject to jamming and with access to plenty of spectrum have little incentive to use them. The antenna pattern for many federal radar systems are regulated by Chapter 5 of the *NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management* ("Redbook").[16] Radar Spectrum Engineering Criteria (RSEC) C and D apply to many federal radar systems.[17] The main requirement for rotating antennas is a median gain of -10 dBi in the "principal horizontal plane". While this amount of sidelobe suppression might have been appropriate in the past when spectrum was less in demand, better suppression is likely available today and could be facilitated by cost sharing between radar users and spectrum sharing parties. Note that nonrotating radars are already subject to 26 dB suppression relative to the main beam.

While the specific performance details, including sidelobe levels, of operational military antennas are appropriately classified, a key question is whether the current "Redbook" limits are the best achievable with today's technology, or a historical goal. We note that level of sidelobe suppression is consistent with a 1958 open source article.[18] Any antenna of finite aperture *must* have sidelobes, although their levels are a function of antenna size, aperture illumination taper, aperture blockage, reflector surface errors and feed misalignment, and reflectivity of feed support.[19] For phased array antennas some of these factors disappear but new factors appear due to the discreteness of the current and phase shifts over the aperture. Radio telescope antennas share many characteristics of radar antennas and low sidelobe levels are useful for both. However, while radar operators can use regulatory tools to limit cochannel spectrum use, radio astronomers can not do so for observations of molecular resonances that are not in primary radio astronomy (RA) allocations. Thus the RA community has been aggressively pursuing novel antenna designs the suppress sidelobes.[20] One recent example is the Robert C. Byrd Green Bank Telescope which achieves 12 dB better suppression than a *similarly sized* conventional antenna.[21] Similar design techniques, as well as lessons learned from military antenna designs, could reduce the sidelobes of radar antennas to facilitate sharing.

Some of these reduction techniques involve increased antenna size which is practical within limits at a cost in many terrestrial radar systems but much less practical in airborne or naval systems. Other techniques increase the complexity and cost of antennas. If the communications and radar systems

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[16] http://www.ntia.doc.gov/osmhome/redbook/ed200801rev201009/5_9_10.pdf Note that unlike the FCC Rules, these requirements are not legally binding on federal users authorized by NTIA in that NTIA can give alternative limits in specific authorizations and the details need not be made public.

[17] Redbook 5.5.3.5 and 5.5.4.5 There is not stated general criteria for radars with rated peak power less than 100 kW. The present requirements are

> Since electromagnetic compatibility considerations involved phenomena which may occur at any angle, the allowable antenna patterns for many radars may be usefully described by "median gain" relative to an isotropic antenna. Antennas operated by their rotation through 360 degrees of the horizontal plane shall have a "median gain" of –10 dB or less, as measured on an antenna test range, in the principal horizontal plane. For other antennas, suppression of lobes other than the main antenna beam shall be provided to the following levels, referred to the main beam:
>
> first three sidelobes--17 dB;
> all other lobes--26 dB."

[18] McCoy, A.; Walsh, J.; Winter, C.; "A broadband, low sidelobe, radar antenna" *WESCON/58 Conference Record* Volume: *2* , Part: 1 (1958) , Page(s): 243 - 250

[19] Shahnaz Bibi ; Nadeem Faisal ; Xie ShuGuo ; "Analysis of Low Side Lobe Reflector Antenna", Multitopic Conference, 2006. IEEE INMIC '06, p. 383

[20] It is assumed that the military radar community has also been aggressive in this area, but since sidelobe performance affects jamming vulnerability there are valid national security reasons to be secretive about sidelobe levels of specific military radars. We note, for example, that the manufacturer of the AWACS radar system refers to its "Ultra-Low Sidelobe Array". (http://www.es.northropgrumman.com/solutions/awacs/assets/AWACS.pdf) No quantitative information on AWACS sidelobes is in the public domain, but a paper from the AWACS manufacturer states that "ultralow" means sidelobe levels "below -40 dB". (Hacker, P.; Schrank, H.; "Range distance requirements for measuring low and ultralow sidelobe antenna patterns"; *IEEE Transactions on Antennas and Propagation*, Volume: *30* Issue: 5 Page(s): 956 – 966, 1982) It is assumed that technology transfer of some of the features of this radar to other federal government radars is possible if key details were kept classified and the nonmilitary user compensated for the marginal cost of improved sidelobe performance through cost sharing with other spectrum users.

[21] http://www.gb.nrao.edu/gbt/gbtdesign.shtml

were designed jointly then cost sharing between the two classes of user could be considered and joint tradeoffs made. While such cost sharing is not possible under current legislation and present FCC and NTIA policies, it is not an inconceivable change either given the present demand for spectrum and the focus on economic growth for both societal reasons and national security reasons as outlines above.

If the communications users had cooperative real time information on the beam azimuth and rotation rate (or in the case of electronically steered beams the future azimuths in general) then the communications users could adjust their temporal and spatial use of the frequency to minimize impact on the radar system. For example, more power could be used when the radar azimuth is antipodal to the communications user and power could be reduced to zero or near zero when the radar azimuth overlaps the communications users. This makes no sense for full duplex voice systems[22], but as stated previously this is not the type of wireless use where there is significant growth is today and is unlikely to be in the future. Packetized communications systems can effectively use this type of intermittent availability spectrum.

Joint design radar and communications signals can also improve the D/U ratios needed for the interference free use of both systems both considering both signal design and antenna polarization. Such a change in D/U protection could increase the amount of communications that could be used on an interference free basis in the radars coverage area and within its bandwidth. When the two types of systems can never be made completely orthogonal in either signal space or electrical polarization, every few dB decrease in signal crosscorrelation and in cross polarization coupling translates into more effective spectrum use. Joint design would allow the tradeoffs and cost allocations to be made to maximize the public interest.

IV. Conclusions

It is in the public interest to maximize spectrum use by developing radar and communications systems designed from the beginning to share spectrum. Joint design would allow the marginal cost increases for the radar systems to be paid by the communications users that directly benefit from more sharing. Under present spectrum regulation, such spectrum sharing and cost sharing may be impractical, but pending legislation recommended by the National Broadband Plan would facilitate such sharing.

[22] Although it should be noted that VOIP-based voice systems could reroute packets to different physical channels during a call. However, voice telephone has time latency requirements that are much tighter than the other categories of mobile communications that are now dominating mobile use.