To whom it may concern:

As researchers, we feel we have an important position as a neutral third party in these proceedings. Our goals are to promote the most efficient and innovative use of spectrum while providing sufficient protection to incumbents. As such, we have the following comments:

1. Channels of operation for white space devices
    a. We believe that the TV white space (TVWS) rules should **only allow portable devices to use channels 14 through 20 *if this operation is approved by a white space database*** (WSDB). We agree wholeheartedly with the spirit of the Commission's proposal and suggest this change only to fix an apparent oversight which would allow sensing-only devices to use channels containing PLMRS equipment.
    b. We believe that it is prudent to also **open up channels 2 through 13 for portable use**. We see no reason to do otherwise. Portable device manufacturers may or may not make use of these channels, but innovators should not need to wait for special regulatory approval to do so.
    c. We support the proposal to **allow white space devices (fixed and portable) to operate on channels 3 and 4**.
2. Operating parameters for white space devices
    a. We **strongly support the FCC's move to provide a variety of (emissions limit, separation distance) pairs**. We believe that this approach offers more flexibility to white space devices while adequately protecting the incumbents.
    b. We believe that **the FCC should define a methodology for calculating the required separation distance given an emissions level and HAAT of the WSD**. We believe database providers should be given the choice to support a small or large number of emissions levels, based on their computational abilities[1]. This approach will allow for maximum flexibility while imposing no extra burden on the database providers.
    c. We believe that **white space devices should only be required to communicate their location to the database, not a proposed power**. In return, the database should provide a set of (max. power, channel) pairs describing what is available at the device's location. This is already done by database providers via PAWS. Furthermore, there is no reason for a device to pre-commit to a power level: operational decisions should be made on the device in real time after all available information has been collected. If databases want to support an additional query mode, e.g. one in which the device proposes a power level, then they should be able to do so.
3. Rural operation
    a. We strongly support the idea of **increasing height and emissions limits in "rural" areas**.
    b. However, **we caution against using the proposed definition of rural**. *Please see our extended comment below on this issue*. Briefly, we instead propose simply expanding the set of (emissions limits, separation distances) to include at least a point at 10 Watts. We see no reason to artificially limit this to some areas.

[1] More precisely, what we mean is that database providers should be free to choose how many different emissions levels they wish to support. For example, a resource-poor database may only support a few levels (e.g. the ones currently defined in the NPRM) while a resource-rich database may support many levels. Since devices will always use the larger of two separation distances if they fall between two pre-defined emissions levels, this approach is still safe for incumbents. At the same time, it allows for database providers to differentiate themselves in the level of service that they can provide.

c. We **recommend expanding this set further to include even higher emissions limits**. As long as the separation distances are adequate for the power and expected device density, this should cause no additional potential for interference. Additionally, since the separation distances are defined in the databases rather than the devices, these separation distances can be adjusted over time if they are found to be inadequate.

4. Location accuracy
    a. We **strongly support the Commission's proposal to consider geolocation methods other than GPS and methods with variable accuracy**. We believe moving to a more general notion of geolocation will promote innovation and competition.
    b. We believe that **devices should be allowed to report their location uncertainty as a polygon or set of polygons.** In the future, devices may be able to prove that they are located within a generic shape. Since location uncertainty directly factors into the amount of recoverable white space, allowing the use of more generic shapes would drive innovation and improve access to spectrum. However, we also propose that support for this type of uncertainty should be a choice left to the database providers. In this way, we are not held back by the "lowest common denominator" among database providers but can move forward to provide the best service possible. *Please see our extended comment below regarding alternative geolocation methods.*
5. Allowing non-white space devices to support white space devices
    a. We believe that **white space devices should be allowed to "tether" to a non-white space device for the purposes of using its Internet connection to contact the database.** Since the communication to the database will be encrypted end-to-end, the device providing the connection need not be certified. For example, a fixed or geolocated portable device may "tether" to a nearby smartphone rather than requiring its own Internet connection.
    b. We also believe that **non-white space devices should be able to help geolocate white space devices**. For example, a user's personal/portable white space device may use the geolocation functionality (e.g. GPS) on the user's smartphone rather than including a costly GPS receiver of its own. Alternatively, indoor devices may use their proximity to a location beacon--which need not be a fixed or Mode II white space device--to approximate their true location. We believe that this proposal has significant potential to promote innovation and economic growth in the white space device market.
6. Alterations to the channel re-check interval
    a. We **agree that a long re-check interval for WSDs may encourage protected entities to over-register** if they feel unable to predict their actual usage needs far in advance. We believe that shortening the re-check interval, even for a few channels, may help with the problem of over-registration.
    b. However, we also believe that **the solution to over-registration of protected entities should not be limited to changing the behavior or permissions of white space devices**. Instead, abuse should be addressed head-on by the Commission.
    c. We believe that **limiting the number of hours a protected entity may reserve without a waiver may help to curb this abuse**. Furthermore, registrants which continually over-reserve -- as shown by reported usage statistics -- should be directly admonished. If abuse still continues, registration privileges may be suspended or withdrawn, or fines may be levied.
    d. We **agree with the precedent set by the change of the re-check interval**. We believe that spectrum availability and protection parameters should be defined in a dynamic way rather than encouraging the assumption that they will not change once enacted.

e. We **propose that the re-check interval be defined as a variable parameter in the response from the white space database**. While mandating this would be heavy-handed, the Commission does have the flexibility to adopt rules which encourage this behavior. For example, a small number of channels could be designated as "fast response channels," requiring a shorter re-check interval, while others require infrequent re-checks. This not only supports device diversity but it also promotes the adoption of more flexible protocols. In this way, the Commission would be able to change the re-check interval(s) in the future without needing to adopt an explicit transition plan (as proposed in §15.37(i)) and thereby hastening the obsolescence of otherwise-compliant devices.

Comments on the proposed definition of "rural area"

In ¶45 of the Part 15 NPRM, the following definition of white space "rural area" was proposed:

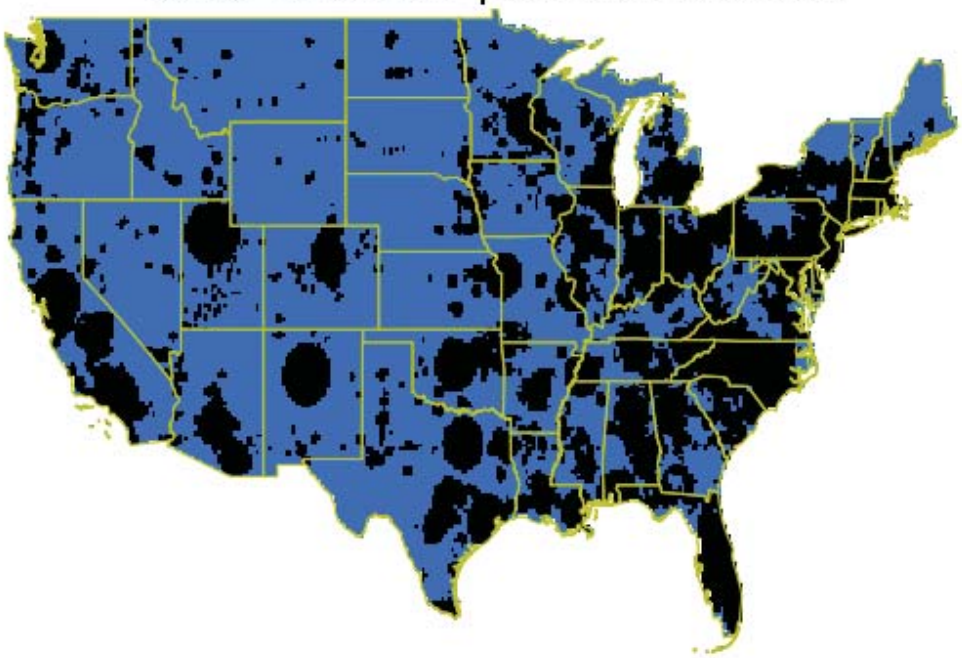
> We propose to identify rural areas for white space devices as those where at least half of the TV channels are unused for broadcast services and available for white space use.

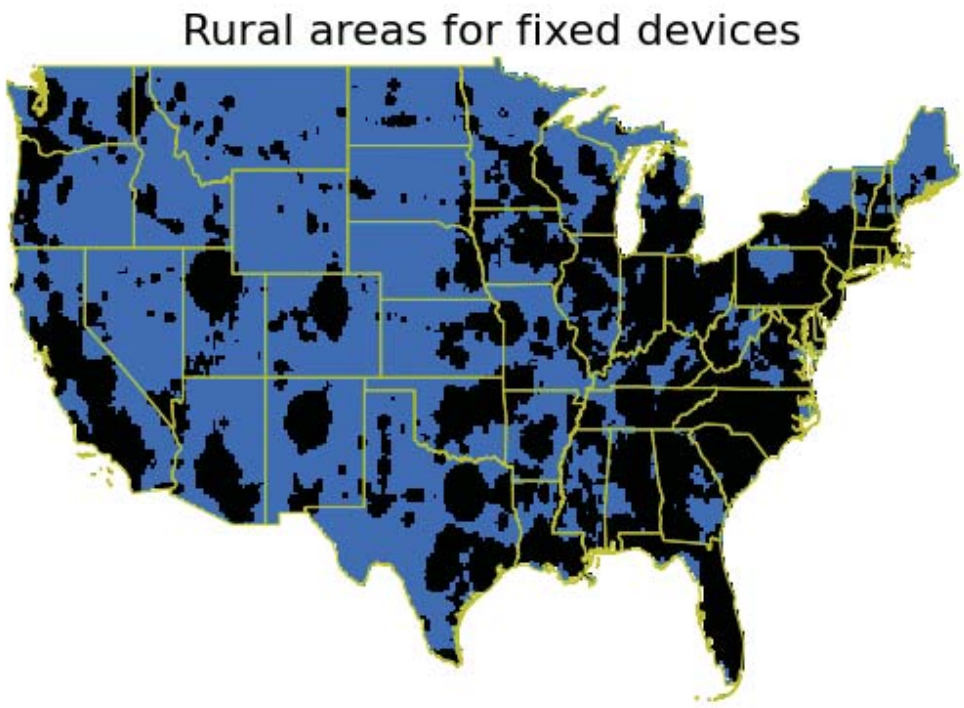
We have identified several problems with this definition for "white space rural," supported by our figures below:

1. Use of the word "rural" is confusing because although there is a strong correlation between truly rural areas and "white space rural" areas, they are not the same. This can be seen by looking at the maps below showing the "white space rural" areas in blue.
2. The definition as stated is unnecessarily complicated. As we understand it, it would be sufficient to say "at least half of the TV channels are available for white space use."
3. Although the "white space rural" areas tend to be in areas with few TV stations, these areas are not necessarily far from the protected contour of TV stations. We support the idea of defining an additional separation distance for "rural" operation for this reason.
4. The locations which are considered to be "white space rural" are erratic in their nature. This complicates system planning for white space device operators which wish to take advantage of the "rural" areas.
5. Finally, we believe that emissions limits should depend only on the distance to co- and adjacent-channel contours rather than the number of TV channels which are available in the region. Creating a dependency conflates the two.

Rather than define specific rural areas, we propose to simply allow white space device operation at 10 Watts if the device is sufficiently far from co- and adjacent-channel contours. This separation distance can be made conservatively large at first and adjusted over time to suit the needs of the primary and secondary systems. This proposal fits within the existing framework for defining protections and requires no new logic within the white space databases.

Rural areas for portable devices





The figures above were produced using WEST (https://github.com/kate-harrison/west), an open-source tool for evaluating the amount of white space available under different regulatory assumptions. For the simple calculations above, we have included only TV station protections (i.e. we have ignored PLMRS/CMRS, wireless microphone, etc. protections). We have also used idealized circular contours based on F-curves for the sake of quick computation. The fixed white space device was assumed to have a 30 meter HAAT.

Comments on alternative geolocation methods

As part of our research at UC Berkeley, we have conducted studies on how to support non-geolocated or weakly-geolocated devices. In particular, we compare the FCC's approach, Ofcom's approach, and a new proposed method which achieves the same protection goals while increasing the amount of recoverable white space for these devices.

This research was published and presented at IEEE DySpAN 2014 in April and can be found at http://inst.eecs.berkeley.edu/~harriska/docs/2014_DySpAN_localization.pdf. We believe that our proposals may help address some of issues related to the indoor operation of devices.

At a high level, our proposal can be summarized as follows:

1. We disagree with the FCC's assumption that slave devices will be near enough to their master that the set of available channels is identical.

2. We agree with Ofcom's approach of generic operating parameters but find them unnecessarily restrictive.
3. White space databases need only return *safe* responses to white space devices, not necessarily the most permissive safe responses. (This sentiment is already reflected in e.g. Ofcom's generic operational parameters.)
4. Hypothetically, if a device knows with high confidence that it is either in Cory Hall on the UC Berkeley campus or in the FCC's headquarters, it is clear how the database should respond: it should allow the white space device to transmit only on channels which are available at both locations. This admittedly silly example demonstrates the heart of our proposal:
    a. The white space access problem is not necessarily a geolocation problem.
    b. White space databases can give answers that protect the primary, even when the geolocation uncertainty is high.
5. White space devices can generate their set of possible locations in many ways. For example, the device may use a combination of max-range-to-master and RF fingerprinting (e.g. WiFi fingerprinting or TV signal fingerprinting). The latter uses measurements of *strong* TV signals to rule out potential slave locations (e.g. "I am definitely in the service area of a station on channel 14, so I cannot be in locations where channel 14 is not viewable").
    1. Note that we do not actually suggest allowing the white space device to generate the set of possible locations. Instead, we envision this functionality sitting in the cloud, either as part of the WSDB or as a separate add-on service. In addition to it being nearly impossible for the device to perform this task itself, we see many benefits in using software as a service that can be continuously evolved as requirements change.
    2. We also envision a richer set of location-relevant data (not just WiFi- and TV signal fingerprinting) which evolves over time to meet consumers' and the Commission's needs and reflects the capabilities of modern technology.

If you would like to learn more about our proposals or our work, please do not hesitate to contact us.

Sincerely,

Kate Harrison and Anant Sahai
harriska@eecs.berkeley.edu, sahai@eecs.berkeley.edu