UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Washington, D.C. 20230

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Federal Communications Commission
Office of Secretary

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

RE: *Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands*, ET Docket No. 03-237

EX PARTE OR LATE FILED

Dear Ms. Dortch:

Enclosed please find an original and four (4) copies of late-filed comments of the National Telecommunications and Information Administration in the above-referenced proceeding. Also enclosed please find a diskette containing a Word file of the comments. A copy and diskette were also sent to Qualex International.

Please direct any questions you may have to the undersigned.

Respectfully submitted,

Kathy D. Smith

Kathy D. Smith

enclosures

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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
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Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands	)	ET Docket No. 03-237

COMMENTS OF THE NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

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EXECUTIVE SUMMARY

The National Telecommunications and Information Administration (NTIA) commends the Federal Communications Commission (Commission) for initiating this proceeding that will examine a more quantitative approach to spectrum management with the goals of providing radio service licensees with greater certainty regarding the maximum permissible interference present in the frequency bands in which they operate and possibly allowing more opportunistic access to the spectrum by unlicensed devices. NTIA believes that properly developed quantitative permissible interference standards could assist the Commission in assessing the degree of potential harm from interference caused by undesired signals. NTIA believes that the interference temperature metric, which quantifies the levels of interference at the licensed user's receiver, should be examined to assess whether it can be used to allow greater access to the radio frequency spectrum. However, NTIA believes that opportunistic use of frequency bands by means of the interference temperature limit is not appropriate for all frequency bands. NTIA offers the following comments in response to the specific issues raised in the Commission's Notice of Inquiry and Notice of Proposed Rulemaking (NOI/NPRM) on the establishment of the interference temperature metric.

NTIA recommends the following:

- Any device authorized to make opportunistic use of spectrum within the interference temperature limits must still be subject to the general conditions of unlicensed device operation.
- Unlicensed devices using the interference temperature model should not be employed in the frequency bands listed in Section 15.205 of the Commission's Rules.

- Initially, the Commission should consider implementing the interference temperature model in the frequency bands that have been transferred from federal government to private sector use in accordance with the requirements of Title VI of the Omnibus Budget Reconciliation Act of 1993 and the Balanced Budget Act of 1997.
- The Commission should not adopt the power levels and dynamic frequency selection (DFS) detection thresholds developed for sharing with radar systems without performing a further analysis that takes into account specific technical factors unique to fixed service (FS) systems.
- Geo-location technology that unlicensed devices can employ to facilitate sharing with the FS can also be employed to protect the radio astronomy observatories monitoring the methanol spectral line in the 6650-6675.2 MHz band.
- The Commission should not adopt interference temperature limits without performing the appropriate supporting technical studies.
- A change in the receiver temperature divided by the receiver temperature ($\Delta T/T$) threshold of 1 percent is appropriate for sharing between unlicensed devices and fixed-satellite service uplink receivers.
- The Commission should issue a follow-on NPRM that builds upon the existing public record established in the NOI on receiver performance requirements to determine the reference receiver performance parameters to be used in establishing interference temperature limits.
- The results of the first phase of NTIA's study on interference protection criteria values for specific radio services be included as part of an NOI to establish

maximum permissible interference levels applicable to the various radio services.

- The parameters of the interference temperature measurement system should be identified for each frequency band and standardized to maximize the usefulness of the measurements.
- Before the interference temperature model is implemented, the rights and responsibilities of spectrum users should be addressed.
- Operational scenarios and maximum permissible interference limits should be developed for each radio service to be used in determining the interference temperature limits.
- When establishing the interference temperature limits, the emissions from licensed and unlicensed systems operating in adjacent or harmonically related frequency bands should be taken into consideration.
- Prior to implementing the interference temperature model, technical issues related to performing the compliance measurements should be resolved.
- The interference temperature limit for unlicensed devices should be established to protect both primary and secondary allocated services within the frequency band.
- The Commission should not use the $\Delta T/T$ levels measured by a satellite receiver to control the operating characteristics of unlicensed devices.
- NTIA and the Commission should identify a list of candidate licensed and unlicensed frequency bands where the emission or noise levels can be measured using standardized measurement systems, and these measurements should serve as a baseline for characterizing the existing emission environment in those bands.

NTIA commends the Commission for initiating this proceeding examining possibilities to expand the options for unlicensed device use while providing certainty and predictability desired by licensed spectrum users. NTIA agrees with the Commission regarding the benefits that could be gained by increasing spectrum access opportunities for unlicensed devices. Implementation of the interference temperature model and the use of interference mitigation techniques such as DFS and geo-location represent a shift in interference management from the transmitter to the receiver. The NOI identifies many technically challenging issues that must be addressed before the interference temperature model can be implemented in a frequency band. These technical issues, include but are not limited to: development of radio service specific reference receiver parameters; development of radio service specific maximum permissible interference limits and operational scenarios; and measurement of the existing radio frequency signal environment in order to establish a proper baseline. Until these technical issues, as well as the rights and responsibilities of spectrum users have been resolved, wide-spread implementation of the interference temperature model will not possible. Because of the sensitive nature of the operations in many of the restricted frequency bands, implementing the interference temperature model would be difficult, if not impossible. However, if the initial implementation of the interference temperature model were limited to specific bands, for example, bands transferred from the federal government, many of the technical issues listed above could be addressed and possibly resolved with minimal impact to incumbent spectrum users. NTIA believes interference mitigation techniques, such as DFS and geo-location, hold great promise for facilitating sharing between licensed and unlicensed spectrum users. However, these techniques should not be employed until the supporting studies examining the specific characteristics of the licensed services and unlicensed device applications have been completed.

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and satellite Frequency Bands	)	ET Docket No. 03-237

COMMENTS OF THE NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

The National Telecommunications and Information Administration (NTIA), an Executive Branch agency within the Department of Commerce, is the President's principal adviser on domestic and international telecommunications policy, including policies relating to the Nation's economic and technological advancement in telecommunications. Accordingly, NTIA makes recommendations regarding telecommunications policies and presents Executive Branch views on telecommunications matters to the Congress, the Federal Communications Commission (Commission), and the public. NTIA, through the Office of Spectrum Management (OSM), is also responsible for managing the federal government's use of the radio frequency spectrum. NTIA respectfully submits the following comments in response to the Commission's Notice of Inquiry and Notice of Proposed Rulemaking (NOI/NPRM) in the above-captioned proceeding.[1]

1. *Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands*, Notice of Inquiry and Notice of Proposed Rulemaking, ET Docket No. 03-237, 18 F.C.C. Rcd. 25309 (2003) ("NOI/NPRM").

I. INTRODUCTION

In this NOI/NPRM the Commission seeks comments on a new interference temperature metric for quantifying and managing interference. The Commission believes that this metric could shift the current method for assessing interference, which is based on the emissions generated by the transmitter, to an approach that is based on the actual radio frequency (RF) environment, taking into account the interactions between transmitters and receivers. As envisioned, the Commission believes that the interference temperature metric could allow non-licensed device operations within licensed frequency bands based on the unlicensed user(s) not exceeding the interference temperature limit.

The Commission, in the NOI portion of this proceeding, requests comment on a number of issues relating to the development and use of the interference temperature metric for managing a possible transition from the current transmitter-based approach for interference management to the new interference temperature metric. The Commission poses questions concerning the development of the interference temperature metric, including the determination of interference temperature limits for specific frequency bands, and an assessment of the cumulative noise and interference environment in RF bands, including standard methodologies for making assessments to support the selection of those limits. In the NPRM portion of this proceeding, the Commission seeks comment on technical rules that would permit higher-powered unlicensed device operation in specific frequency bands used primarily by fixed-satellite uplinks and terrestrial fixed point-to-point links.

The interference temperature metric in and of itself is not a new concept, and has been used extensively in the satellite and radio astronomy services, where the distances from the

receiver to RF sources are very large.[2] For example in the fixed-satellite service a change in receiver temperature divided by receiver temperature ($\Delta T/T$) criterion has been used by the International Telecommunication Union (ITU) as a trigger for coordination of co-primary satellite systems. However, the Commission's proposals to establish and codify interference temperature limits: based on actual measurements of the RF environment and using the RF environment measurements to permit underlaying higher-powered unlicensed devices in bands used by licensed radio services are new concepts that must be evaluated very carefully.

There are several ongoing Federal programs that could benefit from establishing interference temperature limits in some frequency bands. The Department of Defense (DoD) is developing the neXt Generation (XG) program through the Defense Advanced Research Projects Agency (DARPA).[3] Like DARPA's early work on the Internet, XG-based technology is applicable to both military and civilian applications. The National Science Foundation (NSF) is also exploring the technology developments needed for enhancing spectral efficiencies of wireless networks in support of expanding opportunities for new services in the wireless industry. NSF's Networking Technology Systems (NeTS) program is addressing the challenges associated with these networks.[4]

NTIA agrees with recommendations made in the Spectrum Policy Task Force (SPTF) Report that the Commission should explore adopting a more quantitative approach to spectrum

2. The distance between the source in the sky and the receiving antenna on the surface of the earth varies little, and a single temperature can be used to adequately describe the amount of energy coming from the source.

3. XG Working Group, *The XG Vision*, Request for Comments Version 2.0, BBN Technologies, Cambridge, Massachusetts. This document and other information about the DARPA XG program are available at http://www.darpa.mil/ato/programs/XG/rfcs.htm.

4. National Science Foundation, Directorate for Computer and Information Science Engineering, Division of Computer and Network Systems, Research in Networking Technology and Systems (NeTS). More information on the NeTS program is available at http://www.cise.nsf.

(interference) management.[5] Many of the issues raised in the SPTF report were also addressed in NTIA's Spectrum Summit.[6] NTIA believes that properly developed quantitative permissible interference standards could assist the Commission in assessing the degree of potential harm from interference caused by undesired signals. NTIA understands that the interference temperature metric as proposed is to quantify and manage the permissible levels of interference at the licensed user's receivers. NTIA believes that the interference temperature metric should be examined to assess whether it can be used to allow greater access to the RF spectrum. However, opportunistic use of frequency bands by means of an interference temperature metric is not appropriate for all frequency bands. NTIA also believes that the determination of the level of interference that a non-licensed user can or will cause is difficult to ascertain. This level of interference is a function of many factors that include, but are not limited to, the transmit power of the non-licensed user, the propagation loss between the non-licensed and licensed users, the antenna pattern and gain of the licensed and non-licensed users, and possibly the aggregation of interference resulting from multiple users (non-licensed and licensed).

NTIA supports the Commission in its investigation of the interference temperature metric to quantify and manage interference in a more precise fashion and to expand the opportunities for new services in the wireless industry, while at the same time to provide licensed operations with greater certainty regarding the maximum permissible interference level and greater protection against interference. NTIA offers the following comments in response to the specific issues raised in the Commission's NOI/NPRM.

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5. Federal Communications Commission, *Spectrum Policy Task Force Report*, ET Docket No. 02-135, at 5 (November 15, 2002) ("SPTF Report").

6. NTIA hosted a summit on April 4-5, 2002, to help identify the best solutions to challenges posed by management of the nation's airwaves.

II. INTERFERENCE TEMPERATURE LIMITS COULD BE USED AS A MEASURE FOR DETERMINING APPROPRIATE DEVICE CHARACTERISTICS FOR OPPORTUNISTIC USE OF THE SPECTRUM, BUT SHOULD NOT BE CONSIDERED A BASIS FOR DETERMINING NON-INTERFERENCE FROM AN UNLICENSED DEVICE.

In the NOI, the Commission seeks comment on the feasibility of using interference temperature as a general approach to spectrum management. The Commission specifically seeks comment on whether a general metric can be used to gauge the success of the introduction of the interference temperature into a new frequency band. Comments are also sought on whether there is a simple metric that can be used to gauge the effect of these unlicensed devices upon the incumbent services.[7]

The interference temperature model has merit as a measure of received undesired energy, and potentially as a means to determine how a device should or should not operate in order to minimize the potential for interference. However, any device authorized to make opportunistic use of spectrum within the interference temperature limits must still be subject to the general conditions of unlicensed operation. Specifically, persons operating intentional or unintentional radiators shall not be deemed to have any vested right to continued use of any given frequency by virtue of prior registration or certification of equipment, and also these devices may not cause harmful interference, and must accept interference from authorized users of the spectrum.[8] No "safe harbor" approach should be utilized, since an objective of this proceeding is to provide radio service licensees with greater certainty regarding the maximum permissible interference, and greater protections against harmful interference that could be present in the frequency bands

7. NOI/NPRM at ¶ 21.

8. *See* 47 C.F.R. § 15.5.

in which they operate.[9] Additionally, the interference temperature model should not impact the definition of harmful interference, which is defined as "[i]nterference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with these [International] Radio Regulations."[10]

III. THE INTERFERENCE TEMPERATURE MODEL SHOULD NOT BE USED TO FACILITATE UNDERLAYING UNLICENSED DEVICE OPERATIONS IN FREQUENCY BANDS LISTED IN SECTION 15.205 OF THE COMMISSION'S RULES.

In the NOI, the Commission acknowledges that licensees would prefer to see the interference temperature limits in the bands they use set low, while the manufacturers and users of unlicensed devices would prefer to see these limits set high. The Commission requests comment on whether there are some services or frequency bands for which the Commission should continue to use the current interference protection procedures.[11]

Unlicensed devices that would operate under the Commission's proposed interference temperature model would still have to comply with the fundamental conditions of operating under Part 15 of the Commission's Rules. For example, unlicensed devices operating under the interference temperature model would still be required to accept whatever interference is received and must correct whatever interference is caused to licensed services, even if this means ceasing operation.[12] Also, unlicensed devices may not operate in the designated restricted

9. NOI/NPRM at ¶ 1.

10. *See* 47 C.F.R. § 2.1.

11. NOI/NPRM at ¶ 21.

12. *See* 47 C.F.R. § 15.5.

frequency bands listed in Section 15.205 of the Commission's Rules.[13] The restricted frequency bands include bands used to support safety-of-life functions such as aeronautical radionavigation and bands employed by radio services that must function, as a nature of their operation, using extremely low received signal levels. The systems that operate in these frequency bands may be passive, such as radio astronomy, or active, such as satellite downlinks. In these restricted frequency bands, only spurious and unintentional emissions are permitted. The only exception to this prohibition is for devices employing ultrawideband (UWB) technology operating under SubPart F of Part 15 of the Commission's Rules. Unlicensed devices that employ UWB technology, by their very nature, have wide transmit bandwidths and cannot avoid operation in many of the restricted frequency bands. Operation in the restricted frequency bands has also been permitted under specific circumstances.[14]

It is difficult to envision how the interference temperature model as described in the NOI can be implemented to manage interference in the restricted frequency bands without establishing interference temperature limits that are so low that any commercial wireless device would be rendered useless. For example, it does not appear possible to allow opportunistic use of radio astronomy bands and still protect radio astronomy observatories and other passive sensing applications by employing the interference temperature model, due to the nature and extremely low power of the cosmic signals the radio astronomers need to study. The permissible interference levels for primary radio astronomy frequency bands are given in ITU-

13. *See* 47 C.F.R. § 15.205.

14. In the 608-614 MHz frequency band used by radio astronomers for Very Long Baseline Interferometry, the Wireless Medical Telemetry Service is permitted, but operation is limited to health care facilities and frequency coordination is necessary.

Radiocommunications Sector (ITU-R) Recommendation RA.769.[15] Table 1 gives the permissible interference levels, and the corresponding interference temperature limits in several radio astronomy frequency bands.

Table 1.

Frequency Range (MHz)	Permissible Interference Level ($dB(W/m^2Hz)$)	Interference Temperature (K)
608-614	-253	7×10^{-5}
1400-1427	-255	8×10^{-6}
4990-5000	-241	1.7×10^{-5}

The interference temperature levels shown in Table 1 were calculated using the power flux density for the maximum permissible interference level specified in ITU-R Recommendation RA.769, assuming that the radio telescope receives interference through the sidelobe of the antenna (assuming 0 dBi gain). A 2000 second integration time is used in the calculation of the permissible interference levels in ITU-R Recommendation RA.769. If a longer integration time is used, as frequently occurs in sensitive radio astronomy observations, the tolerable interference temperature levels would be further reduced.

NTIA does not believe that wireless consumer devices, on a real-time basis, will be able to measure such low levels of interference temperature, and such measurements are believed to be outside of the range of any practical monitoring station. Therefore, it would not be practical to monitor such low interference temperatures by any of the methods described in the NOI.[16] Even if someday such monitoring capabilities were to become feasible, because of the low interference temperature required to protect radio astronomy and passive operations, few if any

15. ITU-R Recommendation RA.769-1, *Protection Criteria Used for Radioastronomical Measurements* (1992-1995).

16. NOI/NPRM at ¶ 10.

new opportunities could be expected to become available to other spectrum users.

Figure 1 of the NOI illustrates the interference temperature model by showing a "service range" that decreases with distance from the transmitter.[17] This may be applicable to communication systems. However, there is no equivalent service range for radio astronomers and the passive services. The power at the radio astronomy receiver is a line that is parallel to the original noise floor shown in Figure 1 of the NOI, and in fact, may lie well below that noise floor. Communication signals and those that radio astronomers and passive services seek to detect are very different, providing another reason why the interference temperature model should not be applied in the restricted frequency bands. For example, celestial signals are $1x10^6$ to 10^{12} times weaker than typical communication signals and consist of Gaussian noise with little or no modulation.[18] When observing a celestial source, radio astronomers detect small increases in the noise power over the ambient noise at the output of the receiver by performing long integrations (often lasting several hours and even days) by accurately pointing at and tracking the celestial source. By a combination of increased integration time and increased bandwidth, noise fluctuations at the celestial source are reduced by a large factor. By contrast, interfering signals due to communication systems vary in time, either intrinsically, or because they are seen drifting through the sidelobe structure of the telescope, as it tracks the celestial source being observed, and these signals are not likely to average out with time.

In addition to the gains in scientific knowledge that results from radio astronomy and passive sensing, related research spawns technological developments that are of direct and tangible benefit to the public have emerged. For example, radio astronomy techniques have

17. NOI/NPRM at ¶ 15.

18. A few sources such as pulsars, show rapid, periodic variations in time, others show slow variability on the scale

contributed significantly to major advances in the following areas: computerized tomography as well as other technologies for studying and creating images of tissue inside the human body; increasing the ability to forecast earthquakes using very-long-baseline-interferometric (VLBI) measurements of fault motion; and use of VLBI techniques in the development of wireless telephone geographic location technologies that can be used in connection with the Commission's Enhanced-911 requirements.[19] The continued development of new critical technologies by passive scientific observers of the spectrum depends on researchers having continued access to interference-free spectrum.

NTIA believes that there are several technical problems associated with employing the interference temperature model in the restricted frequency bands, such as the limitations in the monitoring systems and the limited commercial viability for unlicensed devices operating at the permissible interference levels required in many of the restricted frequency bands. The prohibition on unlicensed device operations in the restricted frequency bands is the only practical method to protect sensitive operations that must measure extremely low signal levels. Therefore, NTIA does not support employing the interference temperature model to allow unlicensed use in the frequency bands listed in Section 15.205 of the Commission's Rules. NTIA believes that this should not impact the Commission's ability to examine the feasibility of the interference temperature model, since there is sufficient spectrum available outside of the restricted frequency bands.

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of weeks or months.

19. Reply Comments of Cornell University, ET Docket No. 02-135, at 4 (July 23, 2002).

IV. THE FREQUENCY BANDS TRANSFERRED FROM THE FEDERAL GOVERNMENT SHOULD BE CONSIDERED FOR THE INITIAL IMPLEMENTATION OF THE INTERFERENCE TEMPERATURE MODEL.

In the NOI, the Commission seeks comment on whether the introduction of devices employing the interference temperature model should be done in stages to ensure that incumbent radio services do not suffer undue interference. For example, the Commission asks how it should limit the initial introduction of the devices to protect the incumbent systems if the interference temperature were implemented in stages.[20]

Many of the parties that submitted comments in response to the Commission's SPTF Report believe that there are potential problems with the interference temperature model as proposed in the report.[21] These commenters represent a broad class of commercial terrestrial and satellite service providers, equipment manufacturers, and industry associations. Several commenters believe that the adoption of the interference temperature model, to allow the underlaying of unlicensed devices, will degrade the performance of currently deployed systems and may make future systems more costly, or inhibit the deployment of new technologies by

20. NOI/NPRM at ¶ 20.

21. V-COMM L.L.C. Reply Comments, ET Docket No. 02-135, at 7 (February 28, 2003); Cellular Telecommunications and Internet Association Comments, ET Docket No. 02-135, at 10 (January 27, 2003); Cingular Comments, ET Docket No. 02-135, at 17 (January 27, 2003) ("Cingular Comments"); AT&T Wireless Services, Inc. Comments, ET Docket No. 02-135, at 9 (January 27, 2003) ("AT&T Comments"); Telecommunications Industry Association Comments, ET Docket No. 02-135, at 8 (January 27, 2003); Lucent Technologies Inc. Comments, ET Docket No. 02-135, at 2 (January 27, 2003); Motorola Comments, ET Docket No. 02-135, at 13 (January 27, 2003); United Telecom Council Comments, ET Docket No. 02-135, at 5 (January 27, 2003); The Boeing Company Comments, ET Docket No. 02-135, at 8 (January 27, 2003); Lockheed Martin Corporation Comments, ET Docket No. 02-135, at 6 (January 27, 2003) ("Lockheed Martin Comments"); Industrial Telecommunications Association, Inc. Comments, ET Docket No. 02-135, at 11 (January 27, 2003); Verizon Wireless Reply Comments, ET Docket No. 02-135, at 9 (February 28, 2003) ("Verizon Wireless Reply Comments").

incumbent service providers.[22] The incumbent service operators also believe that since the interference temperature model analyzes the "worst case" under current technology and spectrum usage conditions, it could possibly preclude implementing new technologies that may improve spectral efficiency and provide communications at levels that may not be possible today.[23] Even the commenters that support the interference temperature approach believe that more work is needed in defining the noise environment and recommend that the Commission proceed cautiously.[24]

In the NPRM, the Commission proposes to allow underlaying higher-powered unlicensed device operation in selected frequency bands used for commercial fixed service (FS) and fixed-satellite service (FSS) operations in the 6525-6700 MHz band and broadcast auxiliary and cable television relay services in the 12.75-13.25 GHz band (excluding mobile operations in the 13.15-13.2125 GHz band).[25] The 6650-6675.2 MHz band segment is used by the radio astronomy service and the 12.75-13.25 GHz band is used for government and non-government space research downlink operations on a secondary basis. Although the NPRM addresses underlaying higher-powered unlicensed devices in these bands, the Commission's proposals do not address any of the technical issues raised in the NOI for implementing the interference temperature model.

22. Verizon Wireless Reply Comments at 12; Cingular Comments at 25.

23. Verizon Wireless Reply Comments at 14; Lockheed Martin Comments at 7; AT&T Comments at 15; Cingular Comments at 20.

24. WiFi Alliance Comments, ET Docket No. 02-135, at 5 (January 27, 2003); Wireless Communications Association International, Inc. Comments, ET Docket No. 02-135, at 9 (February 27, 2003).

25. NOI/NPRM at ¶ 31.

Many of the concerns raised by the commenters to the SPTF report are similar to those raised by the federal agencies. However, NTIA believes that it is possible to study and develop the interference temperature model on a limited basis before the more general implementation has begun. NTIA recommends that initially the Commission should consider implementing the interference temperature model in the frequency bands that have been transferred from federal government to private sector use in accordance with the requirements of Title VI of the Omnibus Budget Reconciliation Act of 1993 and the Balanced Budget Act of 1997. The transferred frequency bands represent spectrum that at this time has limited commercial usage or has not been transferred for private sector use. Therefore, limiting the initial introduction of the interference temperature model to the transferred bands will allow the Commission to address the many technical issues raised in the NOI while minimizing the impact on incumbent service providers and their customers.

An example of a transferred frequency band where the interference temperature model could be initially employed is the 3650-3700 MHz band. The Commission has an ongoing rulemaking proceeding in which it is considering both licensed and higher-powered unlicensed device operations.[26] Since there are no service rules in place for the licensed or unlicensed users, this band would give the Commission an opportunity to employ some of the techniques proposed in the NOI (e.g., measurement of the RF signal environment).

26. *Unlicensed Operations in the Band 3650-3700 MHz; Additional Spectrum for Unlicensed Services Below 900 MHz and in the 3 GHz Band; Amendment of the Commission's Rules with Regard to the 3650-3700 MHz Government Transfer Band,* Notice of Proposed Rulemaking, ET Docket Nos. 04-151, 02-380, 98-237, 19 F.C.C.

V. HIGHER-POWERED UNLICENSED DEVICES EMPLOYING DYNAMIC FREQUENCY SELECTION MAY BE DIFFICULT TO IMPLEMENT IN THE FIXED SERVICE FREQUENCY BANDS, HOWEVER, EMPLOYING GEO-LOCATION TECHNOLOGY MAY PERMIT SHARING OPPORTUNITIES.

The Commission is seeking comment on employing Dynamic Frequency Selection (DFS) to permit higher-powered unlicensed device operation in the 6525-6700 MHz (6 GHz band) and 12.75-13.25 GHz (13 GHz band) FS frequency bands.[27] Specifically, the Commission proposes to require a minimum detection threshold of -64 dBm for unlicensed devices operating at power levels above 23 dBm and -62 dBm for unlicensed devices operating at power levels below 23 dBm.[28] The Commission tentatively concludes that equivalent isotropically radiated power (EIRP) levels of between 30 dBm to 36 dBm are possible in the FS frequency bands.[29] The 6525-6700 MHz band is used to support public safety and railroad, water, and energy services that are vital to the nation's infrastructure.[30] NTIA believes that there are several areas of the Commission's proposals that require further examination before this approach can applied in the FS frequency bands.

The DFS detection thresholds proposed by the Commission are based on a technical analysis performed to ensure compatibility between unlicensed devices and high-powered federal radar systems. The DFS technique studied in that analysis is applicable to radar systems where the transmitter and receiver are at the same location, and where the propagation path from the

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Rcd. 7545 (2004) ("3650-3700 MHz NPRM"); *see also* 69 Fed. Reg. 26790 (2004).

27. DFS is a mechanism that dynamically detects signals that are received above a specified threshold level and avoids co-channel operation with these systems.

28. NOI/NPRM at ¶ 44.

29. *Id.* at ¶ 47.

30. National Telecommunications and Information Administration, NTIA Special Publication 01-49, *Current and Future Spectrum Use by the Energy, Water, and Railroad Industries* (January 2002).

DFS equipped unlicensed device back to the radar receiver is the same as the path from the radar transmitter to the DFS equipped unlicensed device. In this situation, any shielding (e.g., terrain, foliage, building) that attenuates the signal from the radar to the DFS-equipped unlicensed device would similarly attenuate the unlicensed device transmitter signal that is received at the radar. However, in the FS, the transmitter and receiver are typically separated by tens of kilometers. Since the FS transmitter and receiver are at different locations, the problem of the "hidden transmitter" exists. In the hidden transmitter problem, if the DFS-equipped unlicensed device is blocked from receiving the transmitted FS signal it will be permitted to transmit. When the unlicensed device is permitted to transmit and is close to a FS receiver, it may preclude the FS receiver from detecting the desired signal. It is also possible for the DFS equipped unlicensed device to be located outside of the FS transmitting antenna beam, which would greatly reduce the signal level at the unlicensed device making detection for DFS difficult. In its proposal the Commission does not address the hidden transmitter problem. Before DFS techniques can be employed in the FS frequency bands, the hidden transmitter problem must be addressed.

The DFS detection thresholds proposed by the Commission are based on assessing aggregate interference to radar systems in the 5250-5350 MHz and the 5470-5725 MHz bands from a specific number of unlicensed devices all of which were assumed to be operating well below the EIRP level of 36 dBm proposed by the Commission for operation in the 6525-6700 MHz band.[31] Thus, it is unclear whether these detection thresholds can be applied to sharing with FS receivers without further study. In Appendix A, the results of a link budget analysis are presented that determined whether: the proposed DFS detection threshold is adequate for

31. ITU-R Recommendation M.1652, *Dynamic Frequency Selection (DFS) in Wireless Service Systems Including Radio Local Area Networks for the Purpose of Protecting the Radiodetermination Service in the 5 GHz Band* (2003) ("ITU-R M.1652").

protection of FS receivers based on the proposed power level for unlicensed devices. The analysis in Appendix A also determines the EIRP of an unlicensed device that is necessary to preclude potential interference to FS receivers. Based on the results of the analysis in Appendix A, the detection threshold for the 6 GHz band is -110 dBm and -95 dBm for the 13 GHz band. These detection thresholds are well below the -64 dBm proposed by the Commission. In order to eliminate potential interference to FS receivers, the EIRP levels of the unlicensed devices must be limited to -28dBm/MHz (6 GHz band) and -9 dBm/MHz (13 GHz band). These EIRP levels are lower than the Commission's proposal of 36 dBm for unlicensed device operation in these bands. If the unlicensed device operates at the proposed EIRP level of 36 dBm, separation distances of 28 km (6 GHz band) and 14 km (13 GHz band) are necessary to avoid potential interference.

NTIA recommends that the Commission not adopt the power levels and detection thresholds developed for sharing with radars systems without performing a further analysis that takes into account specific technical factors unique to FS systems. There are several fundamental differences between radar and FS system operations that could make the effective implementation of DFS difficult in bands used by the FS. For example, it is unclear whether a DFS-equipped unlicensed device can be designed with sufficient sensitivity to detect FS signals. There are also technical issues related to the hidden transmitter problem for FS systems, but not for radar systems, that need to be addressed. NTIA believes that higher-powered unlicensed device operation is feasible in the FS bands if the unlicensed device is equipped with geo-location technology. In comments in another Commission rulemaking proceeding, the Institute of Electrical and Electronics Engineers 802.18 Radio Regulatory Technical Advisory Group stated that embedding global positioning system (GPS) technology in unlicensed devices is

technically feasible and could be used to limit the device so it does not transmit when located in or near an area where interference to a satellite receive earth station is likely.[32] This approach could also apply to FS locations, where exclusion zones can be established around each site. Unlicensed devices that employ geo-location technology in conjunction with an online database of the FS site locations can then be prohibited from operating in those areas.[33] The Commission, in another rulemaking, also noted that one of the benefits of cognitive radio would be the ability to determine its location and the location of other transmitters, and then select the appropriate operating parameters such as the power and frequency allowed at its location.[34] This could also be true for the use of the interference temperature model.

VI. OPERATIONAL PARAMETERS THAT ARE UNIQUE TO INDIVIDUAL RADIO SERVICES MUST BE CONSIDERED IN DEVELOPING INTERFERENCE TEMPERATURE LIMITS.

Operational parameters of both licensed services and proposed unlicensed uses are required in order to adequately determine the technical characteristics needed for successful implementation of any interference temperature limits. An example of an appropriate methodology for conducting interference analyses that can be used in setting interference temperature limits appears in the recent 5-GHz Unlicensed National Information Infrastructure (U-NII) proceeding.[35] The analyses used to determine appropriate thresholds for use by U-NII

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32. The Institute of Electrical and Electronics Engineers, Inc. Comments, ET Docket No. 02-380, at 10 (April 17, 2003).

33. One method could be for the unlicensed device to connect to the internet to receive updated FS site location information. Such updates could be done over the air or through a computer with a wired connection (attaching to a universal serial bus port through a cradle as currently done for personal data assistants and cell phones).

34. *Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies*, Notice of Proposed Rulemaking, ET Docket No. 03-108, 18 F.C.C. Rcd. 26859, at ¶ 47 (2003) ("Cognitive Radio NPRM").

35. *Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5-GHz Band*, Report and Order, ET Docket No. 03-122, 18 F.C.C. Rcd. 24484 (2003) ("5

devices employing DFS took into account the appropriate technical characteristics of the radiolocation transmitter and receiver (e.g., antenna pattern, bandwidth, scan rate), as well as the appropriate technical characteristics of the proposed unlicensed use of the band by Radio Local Area Network (RLAN) devices. The results of these analyses indicated combinations of transmit power, antenna gain, RF bandwidth, and measurement integration time that would allow successful sharing between the unlicensed RLANs and the radiolocation systems. Similar analyses would need to be conducted for each frequency band being considered for setting of interference temperature limits. Each analysis, however, would be unique due to differing technical characteristics of various licensed services and various unlicensed device applications, as well as differing propagation characteristics in each frequency band.

The Satellite Link Budget Analysis contained in Appendix B of the NOI/NPRM contains a collection of assumptions that were made in performing the analysis. While it is necessary to make certain assumptions in order to conduct the analysis, some of the assumptions could prove to be incorrect. In particular, the assumptions shown in Table 1 of Appendix B of the NOI/NPRM that were made for the distribution of power levels in unlicensed devices is highly dependent on the type of applications being offered in the unlicensed spectrum. The assumptions made in this instance appear to follow closely the methodology used in determining power distribution in the 5 GHz U-NII R&O.[36] These assumptions, however, were made with

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GHz U-NII R&O").

36. Although the Commission did not indicate its use of the methodology in ITU-R Recommendation M.1652 in the 5 GHz U-NII R&O, it is clear from the DFS parameters adopted in that order that this methodology was used. *See* 5 GHz U-NII R&O at ¶ 29.

the input of the incumbent users of the band, and with the input of unlicensed manufacturers as to how they intended to use the band (i.e., RLANs). The lower output levels were based on use of wireless access cards in laptop computers. In such an application, RF personal exposure limits and laptop battery life limit the use of transmit power. The same assumptions would not hold true for other services, such as Wireless Internet Service Providers (WISPs) where maximum coverage would be accomplished by higher power levels from outdoor antennas mounted on towers or rooftops. This is an example where greater flexibility for the unlicensed user could result in less certainty for the licensed user.

The NOI/NPRM also proposes to use the same DFS detection thresholds determined for U-NII devices in the 5250-5350 MHz and 5470-5725 MHz bands.[37] While the methodology used to determine these thresholds could be applied to other radiocommunication services, these particular thresholds were determined through extensive modeling efforts undertaken by industry, the Department of Defense, and NTIA for the specific sharing scenarios between the radiolocation service and RLANs. The individual thresholds are not necessarily applicable to other radio services operating in other frequency bands.

NTIA believes that there are many radio service dependent operational factors that must be considered in the technical studies used to establish interference temperature limits. NTIA strongly recommends that the Commission not adopt interference temperature limits without performing the appropriate supporting technical studies.

37. NOI/NPRM at ¶ 44.

VII. A THRESHOLD BASED ON A ΔT/T OF ONE PERCENT SHOULD BE EMPLOYED FOR SITUATIONS WHERE UNLICENSED DEVICES ARE SHARING WITH FIXED-SATELLITE SERVICE UPLINK RECEIVERS.

The Commission proposes to permit unlicensed devices operating at higher power levels to underlay in the 6525-6700 MHz and 12.75-13.25 GHz FSS uplink frequency bands. The Commission proposes that a ΔT/T threshold of 5 percent for the aggregation of unlicensed devices be used to assess whether or not sharing is possible. The Commission also performed a link budget analysis using an assumed unlicensed device distribution for the power levels and duty cycles of the individual devices. The analysis computes the number of aggregate co-channel unlicensed devices that are needed to exceed the ΔT/T threshold. The Commission seeks comment on the appropriate level for the ΔT/T threshold to be used and the various assumptions included in their link budget analysis.[38]

Inmarsat is currently procuring its next generation of satellites for launch in 2004 and 2005, one of which will be visible from the United States. These satellites operate in frequency bands that include the 6525-6700 MHz band and are used for a number of mission critical purposes. This band is used to support feeder links for Inmarsat mobile satellite services, as part of the Global Maritime Distress and Safety System (GMDSS), which provides safety-of-life services to the maritime community throughout the world.[39] This band is also used for feeder links to support the Satellite Based Augmentation System (SBAS) signals, which are part of the radio navigation satellite service (RNSS).[40] The SBAS is used to enhance GPS capability (integrity as well as improved accuracy and availability), used for aircraft navigation purposes.

38. NOI/NPRM at ¶ 38.

39. The GMDSS is required by international treaty resulting from Safety of Life at Sea (SOLAS) convention.

40. The SBAS is part of the Global Satellite Navigation Satellite System (GNSS) which will be used for aviation, maritime, and terrestrial navigation.

These feeder links are used in the United States to support the Federal Aviation Administration's (FAA's) Wide Area Augmentation System (WAAS).

NTIA agrees with the Commission that a ΔT/T threshold is appropriate to use when assessing potential aggregate interference to satellite receivers. The ΔT/T concept uses interference allotments to apportion interference to different types of sources and is used in assessing potential interference to FS and FSS systems. The Commission proposes a ΔT/T of 5 percent which is slightly more conservative than the value of 6 percent used as a coordination trigger between co-primary satellite systems. The interference margin in the FSS system is intended to accommodate external sources, such as other mobile satellite service (MSS) systems, downlink interference to earth station from RNSS systems, other FSS systems, and fixed and mobile services. Since there are numerous possible sources of external interference in the FSS band, their available margin is already reduced. NTIA believes that it may be more appropriate to use a ΔT/T value of 1 percent for sharing with unlicensed devices. This would be consistent with the interference allotment approach that the FSS and FS uses for the totality of non-primary (unlicensed) interference sources.[41]

In general, NTIA agrees with the factors included in the Commission's link budget analysis. The assumptions that have the greatest bearing on the results of the analysis are the distribution of unlicensed device EIRP levels and duty cycles, which are used to determine the EIRP level of a single "representative" unlicensed device. The distribution of EIRP levels and duty cycles will be directly related to the type of unlicensed device application that will be

41. ITU-R Recommendation F.1094-1, *Maximum Allowable Error Performance and Availability Degradations to Digital Radio-Relay Systems Arising from Interference from Emissions and Radiations from Other Sources*; ITU-R Recommendation S.1432, *Apportionment of the Allowable Error Performance Degradations to Fixed-Satellite Service (FSS) Hypothetical Reference Digital Paths Arising from Time Invariant Interference for Systems Operating Below 15 GHz.*

operating in the frequency band. Based on the past analysis of U-NII devices and radar systems, the distribution of EIRP levels and duty cycles assumed in the Commission's link budget analysis appear to be representative of unlicensed devices that are predominantly used for lap-top Wireless Access Systems. These EIRP level and duty cycle distributions may not be representative for higher-powered unlicensed device applications that employ omni-directional antennas. For example, devices that would provide wireless broadband connectivity by WISPs, would employ omni-directional antennas to achieve uniform coverage of a particular geographic area.[42] Using higher EIRP levels without the significant antenna gain reduction in the direction of the satellite that the Commission used in their analysis would greatly increase the interference seen by the satellite receiver. In this situation, the increased interference level would reduce the total number of unlicensed devices that could operate before the $\Delta T/T$ threshold is exceeded.

With regard to the link budget, NTIA agrees with the calculations up to the point where the "Allowable Emitters per Beam in RLAN BW" is computed. The numbers computed in the Commission's analysis are 171,544 for the 6 GHz band and 739,832 for the 13 GHz band. The remaining portion of the link budget in question is given in Table 2.

Table 2.

Parameter	6 GHz Band	13 GHz Band
Allowable Number of Emitters per Satellite Beam	171,544	739,832
Available Bandwidth	175	500
Part 15 Reuse Bandwidth in FSS Band	11.67	25
Alternative Polarizations	2	2
Total Number of Unlicensed Systems within CONUS	53,369,095	369,916,129

The "Part 15 Reuse Bandwidth in the FSS Band" factor (third entry in Table 2) is determined by dividing the "Available Bandwidth" factor (second entry in Table 2) by an

42. 3650-3700 MHz NPRM at ¶ 42.

assumed 20 MHz channel bandwidth of the unlicensed devices considered in this analysis. This indicates the total number of unlicensed channels that would be sharing the FSS band. The total number of unlicensed systems in the United States (fifth entry in Table 2) is determined by multiplying the "Allowable Number of Emitters per Satellite Beam" (first entry in Table 2), the "Part 15 Reuse Bandwidth in the FSS Band" factor, and the "Alternative Polarizations" factor (fourth entry in Table 2). For the 6 GHz band case there appears to be an error in the third row entry because 175/20 equals 8.75 not 11.67. Furthermore, it appears that the total number of unlicensed systems for both the 6 GHz and 13 GHz bands is also incorrect.

Table 3 provides what NTIA believes to be the correct calculation of the total number of unlicensed systems.

Table 3.

Parameter	6 GHz Band	13 GHz Band
Allowable Number of Emitters per Satellite Beam	171,544	739,832
Available Bandwidth	175	500
Part 15 Reuse Bandwidth in FSS Band	8.75	25
Alternative Polarizations	2	2
Total Number of Unlicensed Systems within CONUS	3,002,020	36,991,600

The values shown in Table 3 are based on an interference allotment of 5 percent for unlicensed device interference. If a 1 percent interference allotment were used, the number of unlicensed devices that could be permitted would be 606,835 for the 6 GHz band and 7,062,700 for the 13 GHz band.

NTIA agrees with the Commission that a $\Delta T/T$ threshold is appropriate to use when assessing potential aggregate interference to satellite receivers. The $\Delta T/T$ model uses interference allotments to apportion interference to different types of sources, which is an established spectrum management technique for sharing between licensed and unlicensed radio services. NTIA believes that a $\Delta T/T$ threshold of 1 percent is appropriate for sharing between

unlicensed devices and FSS uplink receivers.

VIII. GEO-LOCATION TECHNOLOGY CAN BE USED TO FACILITATE SHARING BETWEEN UNLICENSED DEVICES AND RADIO ASTRONOMY OPERATIONS IN THE 6650-6675.2 MHz FREQUENCY BAND.

As part of the Commission's proposal to allow higher-powered unlicensed device operations in the 6525-6700 MHz band, it requests comment regarding protection of radio astronomy observations in the 6650-6675.2 MHz portion of the band. The Commission specifically requests comment on whether it is necessary to preclude unlicensed device operations in the 6650-6675.2 MHz portion of the band or can suitable technical standards be developed to ensure that harmful interference is not caused to radio astronomy observations.[43]

The 6650-6675.2 MHz band is used for observations of the 6668.518 MHz methanol spectral line. The methanol line is an important tracer of star formation activity. Although there is no allocation for radio astronomy in this segment of the band, this spectral line is listed in ITU-R Recommendation RA.314 among the lines of greatest importance to radio astronomy.[44] International footnote 5.149 also specifically recognizes that administrations are urged to take all practicable steps to protect radio astronomy operations from harmful interference. Emissions from spaceborne and airborne stations can be particularly serious sources of interference to radio astronomy observations.

The U.S. radio astronomy observatories that are observing the methanol spectral line are given in Table 4.

43. NOI/NPRM at ¶ 48.

44. ITU-R Recommendation RA.314-8, *Preferred Frequency Bands for Radioastronomical Measurements.*