**Before the**
**Federal Communications Commission**
**Washington, D.C. 20554**

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| In the matter of<br><br>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 |

# NOTICE OF INQUIRY AND NOTICE OF PROPOSED RULEMAKING

**Adopted: November 13, 2003** **Released: November 28, 2003**

**Comment Date: [75 days from publication in the Federal Register]**
**Reply Comment Date: [105 days from publication in the Federal Register]**

By the Commission: Chairman Powell and Commissioner Copps issuing separate statements. Commissioner Adelstein approving in part, concurring in part and issuing a separate statement.

## INTRODUCTION

1. By this action, the Commission seeks comment on a new "interference temperature" model for quantifying and managing interference. This new concept could shift the current method for assessing interference which is based on transmitter operations, to an approach that is based on the actual radiofrequency (RF) environment, taking into account the interactions between transmitters and receivers. The interference temperature model could represent a fundamental paradigm shift in the Commission's approach to spectrum management by specifying a potentially more accurate measure of interference that takes into account the cumulative effects of all undesired RF energy, *i.e.*, energy that may result in interference from both transmitters and noise sources, that is present at a receiver at any instant of time. This new approach could 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 in which they operate. In addition, to the extent that the interference temperature limit in a band is not reached, there could be opportunities for other transmitters, whether licensed or unlicensed, to operate in the band at higher power levels than are currently authorized. In such cases, the interference temperature limit for the band would serve as an upper bound or "cap" on the potential RF energy that could be introduced into the band. We therefore seek comment on the potential of this new approach to interference control and management to promote more efficient use of the spectrum and to possibly create opportunities for new and additional use of radio communications by the American public.

2. The interference temperature concepts introduced in this proceeding were initially developed as part of the Commission's Spectrum Policy Task Force's (Task Force) work on means for improving the management of the radio spectrum to increase the public benefits derived from use of the spectrum resource.[1] In its Report, the Task Force observed that interference management has become more

[1] *See Spectrum Policy Task Force Report* (*Task Force Report*), ET Docket No. 02-135, November 15, 2002, at p. 1. On November 25, 2002, the Commission issued a public notice FCC 02-322, inviting public comment on

difficult because of the greater density, mobility, and variability of RF transmitters and because users have been granted increased flexibility in using the spectrum.[2] The Task Force presented several recommendations for improving interference management in this changed environment, one of which was for the Commission, as a long term strategy, to shift its paradigm for assessing interference towards an approach that uses real-time adaptation based on actual RF environments, and in particular to adopt a new "interference temperature" metric to quantify and manage interference.[3] In response to the Task Force Report, a number of parties expressed general support for further analysis and study of the interference temperature concept.[4] Other parties oppose the interference temperature concept as impractical and unworkable.[5] We further note that the Commission's Technical Advisory Committee has concluded that introduction of the interference temperature concept is a reasonable approach to defining harmful interference as a function of how the spectrum is actually being used and the designs and margins of particular receivers.[6]

3. In the Notice of Inquiry (Inquiry) phase of this proceeding, we are requesting comment, information, and research on a number of issues relating to the development and use of the interference temperature metric and for managing a possible transition from the current transmitter-based approach for interference management to the new interference temperature paradigm. In particular, we are posing 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 radiofrequency bands, including standard methodologies for making assessments, to support the selection of those limits. We are also requesting responses on issues concerning the process that would be involved in possible transitioning to the new interference control methods in the various frequency bands.

4. A general implementation of the interference temperature approach would involve planning, study of existing RF noise and interference levels and other factors, and transition processes that would take a substantial amount of time to complete. We seek comment on several steps we could possibly take prior to a general implementation that would bring elements of this new paradigm into use in the near term and thereby provide a test bed for this model that can be studied and evaluated before any broader

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the Task Force report. Twenty-eight parties filed comments specifically addressing the issue of the interference temperature concept.

2 *Id*. at 25-27.

3 The Task Force's other principal recommendation for improving interference management was for the Commission to incorporate receiver interference immunity performance into its spectrum policies. *Task Force Report*, at 31. Pursuant to that recommendation, the Commission recently adopted a *Notice of Inquiry* (*Inquiry*) in a related proceeding to begin consideration of incorporation of receiver interference performance specifications into its spectrum policy on a broader basis. *See Notice of Inquiry* in ET Docket No. 03-65, adopted March 13, 2003, FCC 03-54 (released March 24, 2003). In that *Inquiry*, the Commission observed that if the receivers used with a radio service are designed to provide a certain degree of immunity to, or tolerance of, undesired RF energy and signals, more efficient and predictable use of the spectrum can be achieved, as well as greater opportunities for access to the spectrum. It asked for comment, information and research on a wide range of issues concerning the interference immunity performance capabilities of existing receivers, possibilities for improving the level of receiver interference immunity in the various radio services, possible approaches by which desired levels of performance could be achieved, and the potential positive and negative impacts of receiver standards on innovation and the marketplace.

4 *See* National Association for Amateur Radio (ARRL) comments at 8, Agilent Technologies, Inc. comments at 7, HYPRES, Inc. comments at 3-4, Motorola comments at 14, and Wireless Communications Association International, Inc. comments at 10-12.

5 *See* Agere comments at 6, AT&T comments at 12-14, Cingular comments at 18-19, and Verizon Wireless comments at 10-12.

6 *See* Report of the Second Meeting of the FCC Technological Advisory Council III held on July 7, 2003 at http://www.fcc.gov/oet/tac/.

implementation is considered. Therefore, in the instant Notice of Proposed Rule Making (NPRM) phase, we seek comment on technical rules that would establish interference temperature limits and procedures for assessing the interference temperature in specific frequency bands used by fixed satellite uplinks and by terrestrial fixed point-to-point links. We seek comment on whether the operating circumstances of these facilities would allow for simple and reliable measurement of the interference temperature at a variety of receive sites under diverse situations and circumstances. If we ultimately adopt new technical rules, we seek comment on whether unlicensed devices should be allowed to operate at higher power levels than currently allowed by the rules, so long as they do not cause the interference temperature to exceed the established limits.

## BACKGROUND

5. The Commission's policies and rules for managing the radio spectrum, including its efforts to promote spectrum efficiency, traditionally have relied principally on approaches that manage interference by controlling the emissions and locations of transmitters and the frequencies used by specific types of radio operations. Under this model, the Commission has established operational parameters in portions of the spectrum in which the patterns of radio signals, both geographically and technically, are well understood and generally predictable by equipment manufacturers and licensees. In the past, this model generally served well to control interference and to facilitate effective use of the spectrum in environments in which the specific services and operating technology were stable and well defined. However, the dramatic increases in the overall demand for spectrum based services, rapid technical advances in radio systems, in particular the introduction of various advanced modulation technologies, the increased use of spectrum for mobile services, and the need for increased access to the limited supply of spectrum in recent years are straining the effectiveness of the Commission's longstanding spectrum policies in dealing with some allocations and applications.[7]

6. These changes are prompting the Commission to revisit its traditional model and evolve its spectrum management policies to consider more flexible and market-oriented approaches that can provide incentives for users to migrate to more technologically innovative and economically efficient uses of the spectrum. We need to provide opportunities for an ever increasing array of new digital radio technologies and services and to allow licensees to implement and modify these new technologies and services in accordance with the demands of market forces without having to wait for the completion of lengthy ad hoc rule makings or resolution of individual proceedings that hinge on disputes over interference. To meet these needs, we have implemented new licensing schemes under which bands of spectrum are assigned to licensees on a geographic basis and those licensees are provided flexibility to determine the type of services and the technologies and technical implementation designs used to provide those services. The primary restrictions we apply to technical operations under these licenses are those necessary to ensure that interference is not caused to services operating in adjacent geographic areas or in adjacent or nearby frequency bands. These restrictions typically take the form of limits on signal strength at the edge of a licensee's service area and limits on maximum transmitter power, antenna height and out-of-band emissions. These restrictions, in turn, tend to convey certain rights on the other neighboring or nearby licensees which are protected by such rules.

7. To address the challenges of managing interference in radio environments that are increasingly being characterized by flexible service offerings with a multitude of signal waveforms and by high densities of low power RF transmitters with small signal ranges, the Task Force recommended that, as a long term strategy, where feasible, the Commission shift its paradigm for assessing interference to an approach that uses real-time measurements of actual spectrum use and adapt the responses of transmitters and receivers to these measurements.[8] It observed that quantitative standards reflecting real-

7 *Task Force Report* at 11-15.

8 *Id* at 27.

time spectrum use would provide users with more certainty and, at the same time, would facilitate enforcement. Noting that it is the ability of a receiver to select and receive a particular signal that determines whether a signal has been degraded by interference, the Task Force stated that the environment in which a receiver operates should be considered, *i.e.*, RF power generated by transmitters and RF noise sources that is present at the receiver. It further stated that the Commission's rules should specify a more accurate measure of interference that takes into account all the undesired RF energy available to be captured by a particular receiving antenna. To achieve this objective and provide for transition of interference management to more accurate real-time measurements, the Task Force recommended that the Commission adopt a new "interference temperature" metric to quantify and manage interference. To obtain data on the condition of the RF environment in each frequency band that would be used in setting temperature limits, the Task Force recommended that the Commission undertake a systematic study of the RF noise floor. It further recommended that the Commission adopt a standard methodology for measuring the noise floor and create a public/private partnership for a long-term noise (interference temperature) monitoring network and for the archiving of data, for use by the FCC and the public. Finally, the Task Force recommended that the Commission consider the use of receiver standards, especially voluntary standards, to further address interference,[9] and a NOI released earlier this year by the Commission considers the likely costs and benefits of this potential tool for interference management.[10] The Commission's consideration of an interference temperature is another step in this ongoing effort to develop a comprehensive and effective approach to interference management.

## DISCUSSION

8. As part of our efforts to revise our spectrum management policies to address the changes in RF operations and environments that have occurred in recent years, we are now investigating alternative approaches for managing interference. We seek comment on whether it would be necessary to shift our current paradigm for assessing interference from approaches based primarily on transmitter operations towards new approaches that focus on the actual RF environment and interaction between transmitters and receivers, such as the interference temperature metric.[11] Such new approaches could better allow the Commission to enable future uses of the spectrum, while possibly providing a greater degree of certainty to incumbents regarding the RF environment in which they will continue to operate. In the Inquiry portion of the discussion that follows, we first present a description of the interference temperature concept and how interference temperature limits could be used to manage interference. We then discuss and request comment, information, and research on issues relating to possible approaches for a general implementation of interference temperature limits, including questions concerning the development and implementation of the interference temperature metric, the means and criteria by which devices would comply with the interference temperature limits to provide real-time interference protection to licensed services, and methodologies for measuring the cumulative "background noise" and RF interfering signal levels in specific frequency bands and across the radio spectrum. In order to begin our exploration of the process that would be involved in a transition to an interference temperature regime, we seek comment on specific technical guidelines in the NPRM portion of our discussion that could be implemented in the near future for selected frequency bands prior to any possible general implementation of interference temperature limits and real-time adaptation of transmitters to the interference temperature environment.

9. We seek comment on whether the Commission's approach for managing interference should be changed from its current methodology in order to address the changes in spectrum demand and RF operations and environments that have occurred in recent years. The *Task Force Report* recommended

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9 *Id.* at 31.

10 *See Interference Immunity Performance Specifications for Radio Receivers*, ET Docket No. 03-65, 18 FCC Rcd 6039 (2003).

11 As recommended by the Task Force at 27.

that the Commission evolve its spectrum policy toward more flexible and market-oriented spectrum policies that will provide incentives for users to migrate to more technologically innovative and economically efficient uses of spectrum.[12] Although no single regulatory model can or should be applied to all spectrum to achieve these goals, the *Task Force Report* highlighted certain key elements. One such element is the provision of maximum feasible flexibility of spectrum use by both licensed and unlicensed users, subject only to those rules that are necessary to afford reasonable opportunities for access by other spectrum users and to prevent or limit interference among multiple spectrum uses.[13] We seek comment on whether unrealized opportunities exist for unlicensed, low-power users to access spectrum, and whether changes to the Commission's approach for managing interference would enhance access to the spectrum by such users. We also seek comment on whether changes to the present method of interference management would reduce uncertainty that may exist for current licensees in terms of how much interference they will experience in their bands.

A. Notice of Inquiry

10. *The Interference Temperature Metric and Interference Management*. For purposes of this new interference management paradigm, we define interference temperature as a measure of the RF power generated by undesired emitters plus noise sources that are present in a receiver system (I+N) per unit of bandwidth.[14] More specifically, it is the temperature equivalent of this power measured in units of "Kelvin" (K).[15] The emissions from undesired transmitters could include out-of-band emissions from transmitters operating on adjacent frequencies or in adjacent frequency bands as well as from transmitters operating on the same frequency as the desired transmitter. In principle, interference temperature measurements would be taken at various receiver locations and these measurements would be combined to estimate the real-time condition of the RF environment. The degree of certainty of the estimates would depend on such factors as the transmitter signal ranges, the uniformity of signal levels over an area, the density and location of temperature measuring devices and the sharing of the data taken by nearby devices; *e.g.,* through "*ad hoc* cooperative wireless networks." Measuring devices could be designed with features that include or exclude the energy contributions of particular signals with known characteristics; for example, the emissions of operations licensed to use the subject spectrum in a given geographic area.

11. For an interference temperature limit to function effectively on an adaptive or real-time basis, a system would be needed to measure the interference temperature in the band and communicate that information to devices subject to the limit, and a response process would also be needed to restrict the operation of devices so as to maintain the interference temperature at or below the level of the limit. In the simplest case, the entire process would take place within an individual device. That is, the device

[12] *Task Force Report* at 15.

[13] *Id*. Parties have expressed a desire for flexibility and for certainty regarding operating environment. See Report of the Spectrum Rights and Responsibilities Working Group, Spectrum Policy Task Force at 27.

[14] The concept of an interference temperature as a measure of the undesired RF power in a particular band and location is essentially the same as the concept of an "antenna temperature" as described by Wolfram Research. *See*, for example, Wolfram Research at http://scienceworld.wolfram.com/physics/AntennaTemperature.html. Under this concept, antenna temperature is a component of the total noise temperature of a receiver system, which also includes the thermal noise generated within the receiver.

[15] Interference temperature, expressed in units of Kelvin, can be calculated as the power received by an antenna in watts divided by the associated RF bandwidth in Hertz and a term known as "Boltzman's constant" (the value of this constant is $1.38 \times 10^{-23}$ watt-sec/K, also note that 1 K = - 272.15° Celsius). Alternatively, interference temperature can be calculated as the power flux density (e.g., microWatts/$m^2$ over a bandwidth) multiplied by the antenna capture area in meters squared divided by both the associated RF bandwidth in Hertz and Boltzman's constant. An "interference temperature density" can also be defined as the interference temperature per unit area, expressed in units of Kelvin per meter squared, and calculated as the interference temperature divided by the effective capture area (aperture) of the receiving antenna. This quantity could be measured for particular frequencies using a reference antenna and, thereafter, would be independent of receiving antenna characteristics.

would measure the interference temperature at its location and make a transmit/not transmit decision based on this measurement plus the device's own contribution of RF energy. If the result of this analysis were below the interference temperature limit set for that location, the device would transmit. Another approach would be for the receive sites of a licensed service to measure the temperature and communicate those measurements to a central site, where the interference temperature profile for the region would be computed. A message could then be broadcast indicating the temperature values over that region and perhaps whether devices would or could not transmit on particular frequencies. This scenario may be appropriate in services such as those involving fixed point-to-point operations where there are relatively few receive sites in a given area.

12. A third more general case, might be to establish a grid of monitoring stations that would continuously examine the RF energy levels in specified bands, process that data to derive interference temperatures, and then broadcast that data to subject transmitters on a dedicated frequency, again perhaps with instructions how to respond. The transmitted temperature data from this monitoring system could also include the frequency and geographic location of the interference temperature measurement(s) and the measurement bandwidth so that an individual device could compute the rise in temperature due to its own contribution and make a decision to transmit. A somewhat simpler version of the monitoring grid concept might be to equip all transceivers on a network operating with interference temperature "thermometers" and GPS receivers so that they could measure and transmit temperature data on a real-time basis.

13. There are several actions that could be taken in the event that a device determines that its transmissions would cause the interference temperature limit to be exceeded. One approach would be to select a different transmitting frequency or, if none were available, to cease transmitting until the RF environment changed to a state in which a transmission would no longer cause an unacceptable temperature level. Another approach would be to reduce the transmitter power and/or change the direction or shape of the transmit antenna pattern. These capabilities could be implemented by equipping devices with technology such as automatic transmitter power control (ATPC) or with the ability to electrically re-shape antenna patterns. Combining these approaches, a single device could be designed to scan the range of potential operating frequencies before transmitting, compute an estimate of the amount that their operation would add to the interference temperature on each frequency, and select among the frequencies that would allow compliant operation. The device would monitor the interference temperature and if the observed level began approaching or exceeded the limit, could lower its power, switch to another frequency, make an antenna adjustment, or cease transmitting as conditions might warrant.

14. More complex responses than those described above could be taken when considering a coordinated monitoring system. In such a scenario, responses could range from a requirement that all undesired transmitters cease transmitting, to limitations on the number of devices that could operate or the permitted transmitter power, or to restrictions on the operation of unlicensed devices to specific areas. Any of these limitations could be imposed separately, in tandem, and/or on a priority basis. In cases where devices subject to the temperature cap were not equipped to respond on a real-time basis, actions to ensure the environment remained in compliance with the temperature limit could involve restrictions on sales of additional devices if the temperature approached the limit. Alternatively, a process might be established whereby users registered their devices with an appropriate agent who could then inform them to take actions to reduce the interference temperature if needed. In addition, devices could be built to automatically respond to messages distributed through the local mass media services. Two possible examples include messages that could be embedded in the subsidiary communications authority (SCA) subcarrier transmissions of FM radio stations or within the ancillary data services of broadcast TV signals. Many other variations and options are possible for optimizing the monitoring and response process to avoid exceeding the temperature cap.

15. Figure 1 shows how the interference temperature limit approach could be beneficial to licensees.[16] This figure shows the signal of a radio station designed to operate out to a range at which the received power approaches the level of the noise floor that existed at the time the system was built. As additional interfering signals appear, the noise floor has increased at various points within the service area, as indicated by the peaks above the original noise floor.[17] As a result, the station's service reliability and signal coverage have been reduced. The establishment of an interference temperature limit would fix the amount of new interference that the station could experience. That is, the station would be assured of providing service at all locations where its signal exceeded the level of the interference temperature cap.[18] This would assure that the licensed operation would not experience any further degradation or loss of service from new interference, and thereby provide incumbents greater certainty regarding the maximum permissible level of interfering RF energy in the bands in which they operate. Interference temperature limits could also serve as a "worst" case characterization of the RF environment that would provide benchmarks of the operating environment for equipment and system designers. This could aid designers in balancing the numerous technical and economic tradeoffs involved in radio system planning.

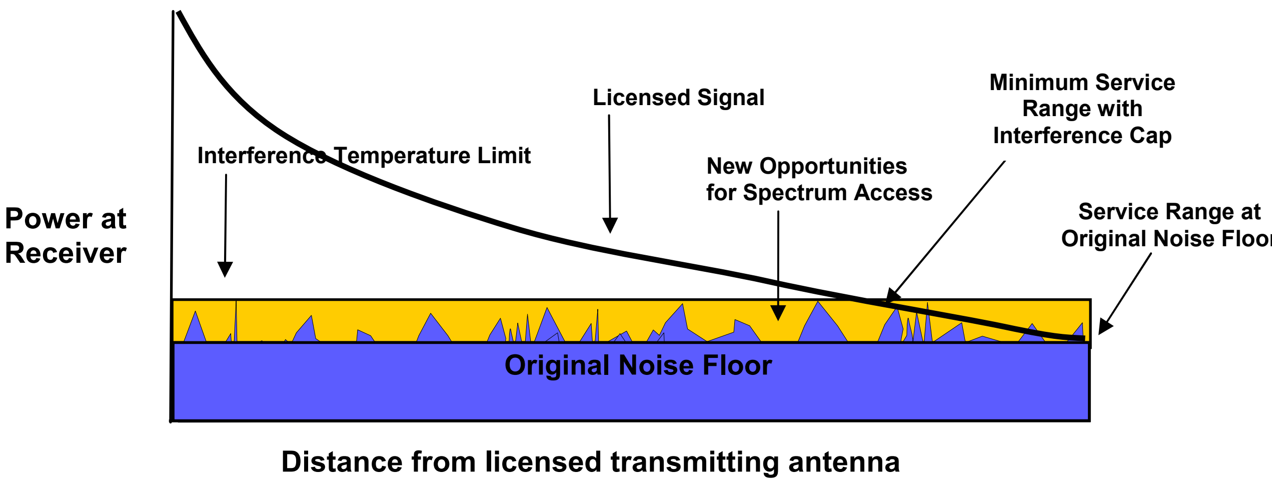


Figure 1

16. This approach could also be beneficial for users of unlicensed devices. In areas where the interference temperature would not have been exceeded, opportunities would exist for additional operation by "underlay" transmitters equipped to monitor the interference temperature and to control their operations so that they do not contribute to a condition where the interference temperature cap would be exceeded. Thus spectrum access for unlicensed users and devices would be increased.

17. We also inquire as to the potential costs and benefits of a policy establishing an interference temperature. In particular, we seek comment on the likely costs and benefits to licensees, equipment

[16] This figure is taken form the *Task Force Report*. *See Task Force Report*, Figures 2 and 3.

[17] Note that unlicensed devices can operate successfully across a frequency band occupied by a higher level signal only if the bandwidth occupied by such devices is greater than that of the higher level signal (which is reasonable to assume in the case of direct sequence digital spread spectrum systems and digital transmission systems that have similar spectrum occupancy characteristics).

[18] More specifically, stations would be able to provide service at locations where their signal would exceed cumulative levels of interfering signals and noise by some margin above which their receivers need to operate. Such operating margins over noise/interference levels are common in radio services, and for this reason most stations would not actually be able to provide service out to a range where the level of their signal equals the level of noise plus interference. Conceptually, the required margin could be included in the formulation of the interference temperature limit for a given service and/or frequency band.

manufacturers and other potentially affected entities that could result from the use of the interference temperature approach or other interference management tools. How would the costs and benefits of an interference temperature approach compare to the costs and benefits under the Commission's current spectrum policy? In addition, we seek comment on whether and how the interference temperature approach could change the current legal framework, regulatory process and general enforcement of rules designed to prevent harmful interference. As we have experienced in recent proceedings involving interference disputes, we recognize that this new approach to interference management could also present issues of competing rights and interests. However, the Task Force Report suggested that clearly defined rights and responsibilities for all spectrum users, particularly with respect to interference and interference protection, should be considered and established to the extent possible and practical.[19] We seek comment as to how the Commission can accomplish this objective and avoid long, drawn out interference disputes without detrimentally affecting reasonable expectations of all interested parties, including expectations regarding the Commission's use of its authority to impose conditions, modify licenses and take other steps to promote greater access to, and more efficient use of, the spectrum.

18. *Issues Concerning the General Implementation of Interference Temperature Limits*. We request comment on using interference temperature limits to manage interference. In this inquiry, the Commission views as two key considerations the potential for unrealized opportunities for unlicensed, low-power users to access spectrum, and the need to provide greater certainty for licensees in terms of how much interference they will experience. Interested parties are invited to submit suggestions for enhancing or modifying the general plan presented above or for alternative approaches. Noting that the Spectrum Task Force indicated that this approach may not be feasible in all bands, commenters are also encouraged to present plans that would tailor interference temperature to specific services. We also request comment and suggestions on how to implement such a plan so as to maximize the benefits for all parties, that is, to protect licensees from interference, provide meaningful benchmark information for equipment and system designers/manufacturers, and opportunities for new operations, including those of unlicensed devices. Commenting parties are also asked to submit information, to the extent it may be available, on the value of these benefits to the respective affected parties.

19. We realize that an approach that uses real-time adaptation based on actual RF environments has not been done in the past and therefore represents a fundamental shift in spectrum management. Although it would be ideal to test this new approach in a frequency band without incumbent services, this is not possible. As technology advances to higher and higher frequencies, investments in infrastructure communications, such as point-to-point systems, point-to-multipoint systems and satellite systems, have to keep ahead of the low-cost technology that is the back-bone of consumer electronics. As a result there are no unoccupied frequency bands within the range of frequencies where low-cost consumer applications can be easily manufactured. Therefore, this new approach must be tried in frequency bands where a significant investment in incumbent communication systems already exists. We request comment on how this concept could be used to promote more efficient provision of service on a licensed basis and how this should be done. More specifically, how could this approach be used with licensing approaches that make spectrum available on 1) an exclusive basis and 2) a coordinated (shared) basis? Also, what approaches would best allow the Commission to transition to spectrum management by the interference concept in existing occupied spectrum bands?

20. In addition to seeking comment in this Notice on the feasibility of using this new concept as a general approach to spectrum management, we seek comment on two frequency bands in which it is more feasible for unlicensed devices to be expanded without causing undue interference to the incumbent licensees. With respect to these bands we ask some general questions:

- Is there is a general metric that can be used to gauge the success of the introduction of the interference temperature devices into a new frequency band?

[19] *See, e.g., Task Force Report* at 3.

- Is there a simple metric that can be used to gauge the effect of these unlicensed devices upon the incumbent services?
- Should the introduction of interference temperature devices be done in stages to ensure that the incumbent services do not suffer undue interference?
- If the introduction were to be done in stages how should we limit the initial introduction of interference temperature devices to protect the incumbent systems?

21. We request comment on what technological factors should be considered in setting interference temperature limits. In general, we would expect that licensees would prefer to see the interference temperature limits in the bands they use set low, while manufacturers and users of unlicensed devices would prefer to see these limits set high. In this regard, we request comment on the following questions:

- What elements should the Commission consider in setting temperature limits for different bands and locations? The Task Force suggested that some of the factors to be considered in setting temperature limits for a band include: 1) the extent of current use; 2) the types of services being offered; 3) the types of licensees (for example, public safety); 4) the criticality of services and their susceptibility to interference; 5) the state of development of technology; and 6) the propagation characteristics of the band. We request comment on whether these factors are appropriate as well as whether other criteria also should be addressed.
- In addition, commenters should address what, if any, technical factors (*e.g.*, power, field strength at boundary areas, antenna requirements, etc.) should be considered in determining the interference temperature limits for a given service, frequency band and geographic area.
- What applications are expected to be filled by unlicensed devices operating under the interference temperature metric?
- Should factors not specified by the Commission's rules, such as typical modulation types for a given service, be considered? If so, commenters should identify these factors and the rationale for including them.
- How should the factors identified be used to determine interference temperature limits? That is, should each factor be considered equally or are some more important than others? Can an equation be developed that uses the identified factors to calculate a temperature?
- Should all the identified factors be used in all cases? Should some factors only be used in some cases? Commenters should provide detailed explanations for including or excluding specific factors in various analyses.
- In bands where several services share the spectrum on a primary or secondary basis, should the interference temperature limit be based on all the licensed services or only on the service most susceptible to interference? How would this be determined? Is the I+N of a primary service meaningful to a secondary service?
- Are there minimum receiver performance criteria that should be considered as a reference in setting interference temperature limits? If so, how should the specifications for such a reference receiver be developed? Or should the Commission use the worst receiver available for a service, or an average receiver, in determining temperature limits? How would such a receiver be identified?
- To what extent should noise and emissions from existing licensed and unlicensed transmitters be a factor in setting interference temperature limits? Should the highest current level of I+N be used as a minimum meaningful level for the interference temperature limit or some other statistical representation of measured values?
- What entities should be parties to the process of setting interference temperature limits? What process should these entities follow in determining the temperature limit for a specific band (*e.g.*, each entity gets an equal vote, some entities' votes have more weight than others, etc.)?
- Should the Commission allow private agreements between licensed and unlicensed users to set interference temperature limits for specific bands and frequencies? If so, are there incentives the

Commission could/should provide to licensees to increase the temperature limit over that set by the Commission?

- How often should interference temperature limits be reviewed?
- What processes should the Commission establish for modifying interference temperature limits? In such cases, what criteria should the Commission consider, how should it weigh those criteria, and who should be parties to modification processes?
- Are there some services or bands for which the Commission should continue to use the current interference protection procedures?

22. We also request comment on the approaches to be used for measuring interference temperature on a real-time basis and, in the case of temperatures derived from measurements at multiple sites, communicating that information to devices that are required to protect the limit. In this regard, we ask commenting parties to address these questions and issues:

- How should the Commission decide on the type of interference temperature monitoring to be required to provide real-time interference control? Commenters should identify the costs and benefits of the three monitoring approaches discussed above and how they relate to different services. Commenters are also encouraged to identify other monitoring approaches.
- Should certain monitoring schemes be specified for certain services? Or should this be solely up to the incumbent licensees?
- How would monitoring systems be funded and who would be responsible for their establishment, operation, and maintenance? Commenters should consider vendors or operators of unlicensed devices and network services, users of such equipment and services, and perhaps licensees.
- What principles/criteria would be used to choose the location of monitoring sites?
- How often should the spectrum be monitored? How large a band should be monitored? How should monitoring differ with the type of incumbent services present in a band? What bandwidth should be used for monitoring (*e.g.*, should measurements be taken with a resolution bandwidth of 1 megahertz)?
- What detection functions, e.g., root mean squared (RMS), peak or average, should be applied in performing noise measurements? What integration or averaging time should be employed with these measurements? What measurement bandwidths are appropriate?
- How would the information from monitoring sites be used to determine real-time interference temperature values for a specific band in a given geographic area and whether established limits were exceeded?
- What spectrum resources should be used to convey monitored temperature information to devices subject to temperature limits? Should dedicated frequencies be used for this purpose?

23. We further request comment on the actions that devices subject to compliance with interference temperature limits should take if the applicable interference temperature limit is exceeded. In particular, we seek comment on the state of development of sensory and control equipment that could appropriately govern the action of emitters in response to real-time interference temperature data, *e.g.*, automatic transmitter power control systems. In addressing the following questions, commenters should seek to balance the requirement that the temperature limits are not exceeded against the need for devices to maintain communications.

- What response should a device take if it determines that exceeding an established interference noise temperature limit, *e.g.*, change frequency, reduce power or place itself in a stand-by mode? Should this response be different if the offending device is a stand-alone device or a device designed to respond to a monitoring system?
- Should a graduated response system be used (*i.e.*, should a device iteratively take measures to bring the interference temperature back into the compliant range or should the strongest measures be taken first)?

- If many devices are operating, is it possible to assign responsibility to specific devices if the temperature limit is exceeded and have those devices take measures to ensure that the temperature is brought back to a compliant level?
- Once an offending device takes measures to bring the temperature back to a compliant level, what protocols should be used to determine when that device may resume operating?
- How should noise temperature limits be enforced? Has technology progressed to the level that the limits could be self-enforced by the radio emitters?

24. *Noise Floor Measurements*. The effective functioning of interference temperature limits as a useful tool for managing interference depends on an understanding of the condition of the RF environment, *i.e.*, the noise floor. For purposes of the interference temperature metric, we believe noise ("N") should be defined as the cumulative environmental RF energy that is generated by sources external to an operator's receiving equipment and generally present in the area around the receiver's antenna.[20] This noise is generally produced by atmospheric conditions, galactic sources, and man-made incidental and unintentional radiators.[21] Specifically excluded from this measure would be all emissions from intentional radiators, *i.e.*, transmitters, as the emissions from such devices can more properly be termed "interfering signals" ("I"), rather than sources of background noise.

25. Noise floor data is useful for assessing the amount of background noise and interference a service is receiving in an area and the variability of those energy sources over both time and location. This information can then be compared to the operating power and receiver performance characteristics of the licensed services to estimate service ranges and the service margin. These estimates can be used to determine whether a service operation is relatively fragile (low margin) or robust (high margin). These estimates of margin can provide an indication of whether a given operation can tolerate additional undesired RF energy from new unlicensed devices or other sources. Where a service has a high service margin, we would generally expect that the interference temperature could be set relatively high (*i.e.*, a significant amount above the noise floor). Conversely, where a service has a low service margin, we would expect that the interference temperature would be set low.

26. We request comment on how to define the noise floor and whether there are considerations that would justify using slightly different definitions for different bands and/or services. We also request comment, information, and research on the levels of the noise floor in the various frequency bands and how those levels vary over time and across geographic regions. While noise floor information is useful in administering our interference temperature limits, we also recognize that measuring and monitoring the noise floor is a substantial, time-consuming, and, in most cases, resource intensive undertaking. We therefore request comment and suggestions for methods to collect this information on a timely, cost

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[20] This value does not include the noise generated by the receiver itself. The level of noise produced by the receiver is not a significant contribution to the noise floor if the level of noise produced by external sources combined with the level of interfering signals is at least 6 to 10 dB greater than the level of the noise produced by the receiver.

[21] Atmospheric noise is generally produced by weather phenomena and is most common on frequencies below 30 MHz. This type of noise is usually sporadic in nature, varying with the season, weather conditions, and time of day. The major source of atmospheric noise is lightning. Galactic noise is produced by solar, cosmic and other extraterrestrial phenomena and generally exceeds atmospheric noise in the VHF spectrum and above. In recent years, man-made noise from both incidental and unintentional radiators can exceed both atmospheric and galactic noise at all frequencies.

An incidental radiator is a device that generates RF energy in the course of its operation although the device is not intentionally designed to generate or emit such energy. Examples of incidental radiators include DC motors, automobile ignitions, mechanical light switches, fluorescent lights, and electric power transmission lines, *see* 47 C.F.R. 15.3(n). An unintentional radiator is a device that intentionally generates RF energy for use within the device, or that sends radio frequency signals by conduction to associated equipment, but which is not intended to emit RF energy by radiation or induction. Examples of unintentional radiators include computers, radio receivers, and other electronic equipment. *See* 47 C.F.R. § 15.3(z).

effective basis or to develop acceptable estimates of this information from methods other than continuous direct measurement and monitoring. We further request comment and suggestions for standard methodologies for collecting and estimating reliable noise floor data that would be consistent with our goals of obtaining this data on a timely and cost effective basis. Commenters should be specific regarding the techniques used to measure the noise floor (*e.g*., providing information regarding spectrum analyzer settings, amount of time monitored, location, etc.).

27. *Determining Harmful Interference*. It is essential to quantify harmful interference in order to develop specific interference temperature levels. Once a level of harmful interference is determined for a specific service, then an interference temperature limit can be set such that any normal increases in the noise floor would not rise to that level. It is important to note, however, that harmful interference is defined by our rules as interference that causes serious detrimental effects as opposed to interference that is merely a nuisance or annoyance that can be overcome by appropriate measures.[22] Furthermore, it is a fundamental reality that every radio communication system must work in the presence of some amount of RF noise and interference. Consequently, communication system designers typically incorporate some built-in operational margin that maintains reasonable performance in the face of variables such as anticipated interference/noise levels, component degradation over time, temperature-related circuit fluctuations, the impact on signal levels from the weather, and the like. In other words, the system design must include some reasonable margin for acceptable performance in a changing environment. Ultimately, however, harmful interference cannot occur if the interference is below a system's threshold of operation. Thus, we seek comment on whether a modest rise in the noise floor, such as envisioned by the interference temperature concept, would generally not cause harmful interference as defined under our rules.

28. More generally, interference can be characterized as an emission from a transmitter that impedes reception of a desired signal to a given recipient. However, as noted above, interference is only considered harmful if it rises to a certain level. In this context, we ask commenters to address the following questions:

- For a given service in a given frequency band, how much interference can be tolerated before it is considered harmful? If the determination of harmful interference would be based on specific quality of service levels, we request comment on the rationale used to justify the recommended constraints. The commenting parties should note the specific frequency bands and services to which their comments apply.
- When performing interference studies, what assumptions should be made regarding operating scenarios? For example, commenters should address the duty cycle to be assumed for the desired and undesired transmitters. What assumptions should be made about whether and/or what percentage of antennas might be aligned under typical operating conditions such that there is main beam coupling between undesired transmitters and desired receivers?
- Can interference from a transmitter be distinguished from naturally occurring noise?
- Can a statistical approach to developing temperature limits be developed? If so, what parameters need to be developed? How would such an approach be applied?
- Should the interference temperature limit be set at level that quantifies "harmful interference" or some other benchmark, or "safe-harbor" level that would constitute less than harmful interference?

B. Notice of Proposed Rule Making

29. *Introduction*. As explained above, we seek comment on whether the interference temperature concept potentially could offer many benefits for management of the radio spectrum. We recognize, however, that it will take a significant period to develop the underlying information, analyses and policy

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[22] *See* 47 C.F.R. § 2.1 (c).

plans needed to fully implement the interference temperature concept across all feasible frequency bands. In this regard, the study of noise floors in the various frequency bands, the establishment of interference temperature levels and related policies, and the development of transition processes will require substantial effort and time to complete. Furthermore, additional time will be needed to develop and implement the monitoring networks, technologies, and devices such as those described above for detecting and relaying interference temperature information to central control stations that would forward this information to transmitters to control the level of RF emissions.

30. Nonetheless, we also seek comment on whether it may be feasible and desirable to begin the process of introducing the interference temperature approach on a limited basis now in selected bands, even as we begin the study and development activities that will support the more general implementation of this new paradigm. In this regard, we seek comment on if it is possible to first introduce the interference temperature concept on a limited basis without full implementation of real-time monitoring of the interference temperature or feedback control of transmitters and prior to completion of our studies of the noise floor. The approach used in this first step would establish an "interference temperature" or equivalent metric based upon the communications margins needed by the existing licensed operations and apply restrictions on unlicensed devices that would minimize the likelihood that their operation would result in an increase in interference temperature that could exceed the necessary operating margin of the licensed services. The proposed restrictions on unlicensed devices would include limiting the transmitter output power and requirements to use transmit power control (TPC) and dynamic frequency selection (DFS). In addition, other requirements that might prove beneficial could include limits on the number of unlicensed devices, as well as duty cycle restrictions that would insure that these initial interference temperature experiments do not cause harmful interference to licensed services. As noted above, we seek comment on how these first steps could provide additional opportunities for operation of unlicensed devices and, perhaps more importantly, provide valuable information and experience to guide our formulation of approaches in the next phases of this effort.

31. *Discussion*. As discussed more fully below, we propose to apply the new interference temperature approach described herein to unlicensed operation within the fixed (FS) and fixed satellite service (FSS) uplink band at 6525-6700 MHz and the FS, FSS, and BAS/CARS band at 12.75-13.25 GHz (excluding 13.15-13.2125 GHz). These bands were chosen because we believe they offer the possibility to implement in a simplified way the interference temperature concept and approach. We seek comment on the appropriateness of these bands and whether additional frequency bands could be suitable for testing the concept of interference temperature.

32. In this regard, we believe that it is beneficial to look at frequencies where FSS satellite uplinks are the predominant use. In those instances, the licensed receiver being protected is located on the satellite in space. Consequently, the receiver would not be located in close proximity to any potentially interfering unlicensed device. Given the significant distances involved and the typical satellite antenna characteristics, the satellite receiver would "see" the cumulative effect of the RF signals from all unlicensed devices on the ground. Therefore, it is possible to develop a simplified interference temperature approach for the satellite receiver and FSS uplink operations by aggregating the interference contributions of a large number of unlicensed devices over a wide geographic area.

33. More specifically, as indicated in the Notice, interference temperature is a measure of the RF power generated by undesired emitters plus noise sources that are present at the input of a receiver system (I+N) per unit of bandwidth.[23] In the case of satellite receivers, we note that the typical receiver noise temperature is a known parameter that can be used to determine an interference temperature threshold. Indeed, this parameter is the basis of the ΔT/T criterion used by the International Telecommunications Union (ITU) to determine whether coordination between systems is required.[24] Furthermore, as noted

[23] *See* ¶ 10, *supra.*

[24] The trigger for coordination with co-primary satellite services used by the ITU is 6% ΔT/T.

above, since a satellite-based receiver will generally "see" large geographic areas of the CONUS, it is possible to analytically aggregate the impact of a large number of unlicensed devices on the ΔT/T criterion. [See Appendix B] Given this knowledge of the satellite receiver's noise temperature characteristics, it is possible to examine, as we do below, what number and power levels of unlicensed operations could be accommodated without, in the aggregate, resulting in a ΔT/T value for the satellite receiver that exceeds a selected interference threshold. In other words, in scenarios where protection of satellite receivers is of concern, we believe that use of a ΔT/T criterion could serve as a reasonable mechanism for approximating a first-step "interference temperature" limit - but without relying upon adaptive, real-time monitoring that would be used in a full-fledged approach.

34. We also believe that bands used for certain terrestrial fixed operations would be suitable for our first-step implementation of the interference temperature concept. The key simplifying benefit of dealing with fixed operations is the fact that such operations are generally static and well-defined such that reasonable assumptions can be made about their locations and technical characteristics. In these bands, fluctuations in the interference temperature can be compared to fluctuations in C/(I+N) or (S/I). Given a knowledge of, for example, the S/I characteristics of typical receivers, it is possible to examine what maximum power levels could be accommodated for an unlicensed device without exceeding the signal margins required for satisfactory operation and therefore without causing interference to such services. Once a value for the interference threshold of a typical licensed receiver is established through consideration of the required signal margins, it is possible to utilize a measurement of the ambient fixed signal levels to determine whether operation of an unlicensed device of known characteristics would exceed the "interference temperature" signal threshold for a licensed receiver. This transmit/not transmit decision could be made in real-time by unlicensed devices that incorporate DFS.[25] As implemented here, the DFS threshold of an unlicensed device would be adjusted so that the device would not transmit if the detected fixed signal level exceeds an established threshold. In this manner, the DFS threshold is functionally equivalent to the interference temperature limit. Consequently, the transmit/not transmit decision made by the DFS feature ensures that the S/I or other chosen metric for licensed receivers is not adversely impacted.

35. *Proposed Bands*. Using the concepts described above for a ΔT/T limit for satellite uplink operations and a DFS threshold for other services, we propose to apply the new interference temperature approach described herein to unlicensed operation within the FS and FSS uplink band at 6525-6700 MHz and the FS, FSS, and BAS/CARS band at 12.75-13.15 GHz and 13.2125-13.25 GHz.[26] This action could enable higher power and more diverse unlicensed operations in these bands and create opportunities for new technologies. For example, we believe that these bands could be useful for many consumer and business unlicensed applications, such as high-speed data and video. Further, we believe that the incumbent operations in these bands can tolerate an expansion of unlicensed operation, both in number of devices and their power without suffering harmful interference.

36. *Incumbent Operations in the Proposed Bands*. The 6525-6700 MHz band is allocated internationally and domestically to FS and FSS (Earth-to-space) operations on a primary basis for non-Federal Government use. However, this band is predominantly used for FS operations. These FS operations consist of the Domestic Public Fixed Radio Services, the International Fixed Public Radiocommunication Services, and the Fixed Microwave Services under Parts 21, 23, and 101, respectively, of our regulations. The services in this band are typically provided by, among others, industrial, governmental and transportation related licensees. Finally, we note that the 6650-6675.2 MHz

[25] DFS is a feature that dynamically instructs the transmitter to switch to another channel whenever a particular switching threshold condition (such as, for example, the prevailing ambient interference level - or any other specified criterion) is met.

[26] We are not proposing to permit unlicensed operation in the 13.15-13.2125 GHz band at this time as that band is allocated predominantly for BAS/CARS mobile operations.

segment of this band is used by the radio astronomy service.[27] The 12.75-13.25 GHz band is allocated internationally and domestically to FS, FSS (Earth-to-space), and mobile services on a primary basis for non-Federal Government users.[28] In addition, this band is assigned and coordinated through the Interdepartment Radio Advisory Committee (IRAC) for Federal and non-Federal Government use for space research (deep space) (space-to-Earth) on a secondary basis.[29] The band currently supports a variety of different systems operating pursuant to each of these allocations. These systems include both geosynchronous orbit (GSO) and Non-GSO (NGSO) satellite systems under Part 25 of our rules, broadcast auxiliary systems (BAS) under Part 74 of our rules, cable TV relay systems (CARS) under Part 78 or our rules, and fixed microwave systems under Part 101 of our rules. Because of the extensive sharing of high power systems already present in these bands, we believe that additional unlicensed devices, even those operating above the current Part 15 power limits, will be able to successfully share spectrum with incumbent users using this new interference temperature approach.[30]

37. The technical rules for these bands vary by service. In broad terms, fixed stations operating in the 6525-6700 MHz band as well as BAS, CARS, and FS stations operating in the 12.75-13.25 GHz band may operate at power levels up to 85 dBm equivalent isotropic radiated power (EIRP).[31] These stations are required to employ directional antennas. FSS satellite uplinks have no limit on transmitted power in the direction of the satellite, but must limit EIRP toward the horizon.[32] Mobile stations can operate with EIRPs as high as 75 dBm.[33] In contrast, the current rules limit unlicensed operation in the 6525-6700 MHz and 12.75-13.25 GHz bands to emissions of -41.25 dBm, which is 126.5 dB lower than the maximum emission level permitted for fixed BAS, CARS, and FS stations.[34] Therefore, in light of the great disparity in magnitude between permissible emission levels for licensed versus unlicensed devices, sound engineering judgment intuitively suggests that the 6525-6700 MHz and 12.75-13.25 GHz bands can support expanded unlicensed operations enabled by an interference temperature approach without detrimental impact to incumbent operations.

38. *Use of ΔT/T Limit for FSS Operations in the 6525-6700 MHz and 12.75-13.25 GHz Bands*. With regard to the protection of licensed FSS uplink operations and satellite receivers, we believe that establishing a ΔT/T threshold as described generally above could serve as an effective "interference temperature" limit. In particular, our preliminary analysis indicates that a large number of unlicensed

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27 *See* 47 C.F.R. § 2.106, note 5.149

28 *See* 47 C.F.R. § 2.106.

29 *See* 47 C.F.R. § 2.106, note US251. The footnote states that the band is allocated to the Federal and non-Federal Government space research (deep space and space-to-Earth) service for reception only at Goldstone, CA.

30 FSS systems in geosynchronous orbit (GSO) in this band are limited to international systems. *See* 47 C.F.R. § 2.106, note NG104. Non-GSO FSS systems in this band are limited to gateway stations. See 47 C.F.R. § 25.202. A gateway earth station is an earth station complex consisting of multiple interconnecting earth station antennas supporting the communication routing and switching functions of a non-geostationary satellite orbit fixed-satellite service (NGSO FSS) system as a whole. See 47 C.F.R. § 25.201.

31 *See*, *e.g.*, 47 C.F.R. § 74.636. Typically, BAS and CARS stations operate with EIRPs 10 to 15 dB below the maximum permissible limits.

32 *See* 47 C.F.R. § 25.204(a). Earth stations must limit emissions to 70 dBm in any 4 kHz band for $\theta = 0^o$ and to $70+3\theta$ dBm in any 4 kHz band for $0^o < \theta \leq 5^o$; where θ is the angle of elevation of the horizon viewed from the center of radiation of the antenna of the earth station and measured in degrees as positive above the horizontal plane and negative below it.

33 *See*, *e.g.*, 47 C.F.R. § 74.636.

34 *See* 47 C.F.R. § 15.209. The limit specified for frequencies above 960 MHz is 500 uV/m and is measured at 3 meters using a 1 MHz resolution bandwidth. This is equivalent to an EIRP of -41.25 dBm/MHz. It also is possible to operate intermittent unlicensed systems at slightly higher power levels under 47 C.F.R. § 15.231, which allows periodic use above 70 MHz. The 126.25 dB difference expressed above does not take into account different FS bandwidth characteristics which could increase or decrease this value.

devices operating with EIRP emission levels possibly as high as 30 dBm to 36 dBm (1 W to 4 W) could be accommodated without exceeding a reasonable ΔT/T "interference temperature" threshold that might be established for FSS systems.[35] A sample link budget analysis that illustrates the potential for these bands to accommodate additional uses is presented in Appendix B. We note that the results obtained are based on an assessment of an acceptable level of aggregate interference threshold of 5% for ΔT/T.[36] This particular interference value was chosen because it is less (i.e., more conservative - or more protective) than the 6% ΔT/T figure used by the ITU for requiring coordination between satellite systems, recognizing the generally lower regulatory status of Part 15 devices.[37] We seek comment on an appropriate interference temperature threshold that will afford sufficient protection to licensed satellite operations, and in particular on whether the 5% value used in Appendix B, or another value of ΔT/T, for example 3% or 1%, would be more appropriate. We also seek comment on the various assumptions made in the link budget analyses appearing in Appendix B, particularly concerning the power emission distributions and other technical characteristics of hypothetical unlicensed operations in the band.

39. We also believe that FSS sharing with unlicensed operations is facilitated by the way licensed satellite facilities operate in these bands. As mentioned above, the use of these bands is limited to international systems for GSO satellite systems and to gateway stations for NGSO satellite systems. We request comment on our assumptions and general analysis regarding sharing between high-powered unlicensed devices and satellite uplinks. If commenters believe that the analysis is flawed or should be conducted differently or by using different assumptions, we request detailed technical explanations and accompanying analysis to support these claims. In addition, we do not believe that our proposals will be detrimental to the space research operations at Goldstone, CA.[38] Because Goldstone is located in a rural location with natural shielding by virtue of its location in a valley, very few, if any, unlicensed devices would be operated in locations that could impact its operation. We request comment on this tentative conclusion.

40. *Use of DFS Threshold for FS Operation in the 6525-6700 MHz and 12.75-13.25 GHz Bands*. With respect to terrestrial fixed systems in these bands, a number of considerations support our belief that establishing a DFS threshold for unlicensed operations as described generally above could serve as an effective "interference temperature" limit. First, we note that significant sharing among licensed FS operations currently exists at the much higher power levels previously cited. More specifically, we believe that the use of relatively large, high-gain antennas in the 6525-6700 MHz and 12.75-13.25 GHz bands by existing licensees makes such operations highly immune to interference – especially from the relatively low power unlicensed devices contemplated by this proceeding. Second, due to the generally isolated siting of fixed point-to-point receive antennas, it is expected that the likely minimum separation distance between the antenna of a fixed point-to-point receiver and an unlicensed device would typically be relatively large, perhaps on the order of one hundred meters or more. Thus, the emissions from any unlicensed transmitter could be expected to be greatly attenuated before reaching an FS receive antenna. For example, if an unlicensed transmitter operating at 6600 MHz is located 100 meters from the fixed station receiver, the unlicensed emission will be attenuated by approximately 89 dB before it reaches the

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35 We note, for example, that the sample analysis in Appendix B suggests that approximately 53 million unlicensed devices could operate in the 6525-6700 MHz band and 370 million unlicensed devices could operate in the 12.75-13.25 GHz band.

36 The interference threshold ΔT/T is a measure of the amount of interference that can be tolerated by the satellite system. ΔT/T is related to the increase in system noise temperature and corresponds to the interference-to-noise ratio, I/N.

37 *See* n. 24, *supra*.

38 Goldstone is operated by the Jet Propulsion Laboratory, part of Cal Tech., and funded as the NASA deep space research center.

fixed station receiver.[39] Similarly, if an unlicensed transmitter operating at 13 GHz is located 100 meters from the fixed station receiver, the unlicensed emission will be attenuated by approximately 95 dB before it reaches the fixed station receiver. Third, we believe that the divergent path geometries that are likely to occur between a typically sited FS antenna and a close-proximity, ground-based, unlicensed transmitting antenna will result in most unlicensed devices being located considerably farther than 20 degrees off-axis from the centerline of any FS receive antenna. At an off-axis angle of 20 to 30 degrees, fixed stations operating in the 6525-6700 MHz band are required to attenuate emissions by 32 to 36 dB and stations operating in the 12.75-13.25 GHz band are required to attenuate emissions by 30 to 36 dB, depending on the antenna category.[40] We also recognize that it is possible that an unlicensed transmitter could be located, for example, within a building and that a fixed station receiver could be located on top of that building. Under these circumstances, the straight-line path length between the licensed and unlicensed antennas in this latter example could be relatively short. However, the high level of shielding of the unlicensed emission provided by the building and the expected high angular off-axis location of the unlicensed emitter from the fixed station receiving antenna should provide sufficient attenuation to the unlicensed emission to prevent it from causing harmful interference.

41. We believe that our assumptions above regarding minimum separation distances and off-axis locations from the FS receive antenna are conservative. It is likely that greater separation distances would occur under actual operating conditions. Further, we recognize that unlicensed devices would not all be in operation at the same time; would not have their emissions intentionally directed towards the fixed service receiver; and could have different path attenuations due to varying intervening objects between them and the FS receiver. We also believe that the unwanted emissions received by the FS receiver will be dominated by the emissions from the closest device and that the real-world antenna off-set attenuation values will be greater than the minimum values required under our regulations. Accordingly, we believe that our assumptions are conservative and represent worst case, as opposed to typical, conditions. We seek comment on the validity of these general assumptions. More specifically, using these figures as a proposed starting point, we seek comment on what amount of attenuation and assumed minimum typical separation distance would provide an appropriate baseline for deriving interference temperature values to protect licensed services from harmful interference.

42. We also note that the minimum signal to interference (S/I) ratio necessary to prevent harmful interference to a fixed station is dependent on the type of modulation employed by the fixed station. Some systems, especially those employing error correction codes and other interference mitigation techniques are highly robust and can operate in the presence of an undesired signal that is considerably higher than the level of the desired signal without experiencing harmful interference. In view of the typical usage by FS stations of low modulation indices and/or amplitude modulation, our general experience indicates that a S/I ratio in the range of 30 dB to 50 dB should be more than sufficient to ensure that harmful interference is not caused to a fixed service operation.[41] Comments are requested on the appropriate minimum S/I value to use and under what circumstances. Comments supporting particular minimum S/I values should provide examples of the necessary minimum S/I of existing

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[39] Free space attenuation over a line-of-sight path equals 20 log $[(4 \pi D)/\lambda]$ dB where D is the distance in meters and $\lambda$ is the wavelength in meters. The wavelength can be determined by dividing the speed of light, 3.00 x $10^8$ meters/second, by the frequency of the emission in Hertz. It should be noted that free space propagation provides a conservative estimate of the attenuation of the emission and that it is likely that the emission levels from an unlicensed device would attenuate more rapidly with distance than shown by these calculations.

[40] *See* 47 C.F.R. §§ 74.641 and 101.115. We used the lower values for the purpose of our illustrative analysis herein.

[41] The signal level from the unlicensed device that is received by the fixed receiver, $S_U$, relative to the signal level of the desired signal, $S_D$, equals the S/I which must exceed 30 to 50 dB, *i.e.*, $S_D$(dBm) – $S_U$(dBm) = 30 to 50 dB. It is also assumed that the received desired signal level is sufficiently above the thermal noise floor of the receiver that this noise level may be excluded from the calculations. It also should be noted that our reference to S/I is independent of fade margins.

systems in their analysis. We also ask that commenting parties include a description of how the appropriate choice for an S/I threshold might vary with changes in the type of modulation employed by the undesired emissions as well as any supporting test data.

43. For illustrative purposes, combining these assumptions in a link budget analysis indicates that an unlicensed emitter 100 meters away from a 6525-6700 MHz FS receiver should be able to transmit at a power level of as much as much as 91 dB to 71 dB higher than the level it receives from an FS transmitter without causing harmful interference to the associated FS receiver.[42] Similarly, an unlicensed emitter 100 meters away from a 12.75-13.25 GHz FS receiver should be able to transmit with a power level of as much as 95 dB to 75 dB higher than that received from the FS transmitter without causing harmful interference to the associated FS receiver.[43] Thus, if the FS signal level at the unlicensed device is -77 dBm, the unlicensed devices should be able to transmit with a minimum signal level of 14 to -6 dBm in the 6525-6700 MHz band and 18 to -2 dBm in the 12.75-13.25 GHz band without causing harmful interference to FS reception. This would hold true even if the unlicensed transmitter is operating on a channel currently in use by a fixed station. We seek comment on the merits of this tentative result as well as on the validity of our rationale. Commenters may wish to explore whether other approaches could be used to derive appropriate values for an interference temperature limit in this band.

44. Furthermore, if unlicensed devices were designed to first monitor (*e.g.*, listen-before-talk, or "sniff") the authorized spectrum to determine the levels of existing RF emissions, they could employ DFS to adjust their frequency of operation to ensure that operation occurs on unoccupied channels.[44] The detection threshold employed within the DFS could be adjusted to accommodate the overhead margins for unlicensed operations calculated above to ensure that the emissions from the unlicensed emitter do not exceed the interference threshold at the fixed receiver. We seek comment on requiring a minimum DFS detection threshold of -64 dBm for unlicensed devices operating at output levels equal to or exceeding 23 dBm and -62 dBm for unlicensed devices operating at output levels below 23 dBm. We further propose that the detection threshold is the received power averaged over 1 millisecond referenced to a 0 dBi antenna. We note that these values generally are consistent with our proposals for DFS employed with UNII operation proposed in the 5470-5725 MHz band and believe these levels would provide adequate protection to FS operations at 6 and 13 GHz.[45] We seek comment on the merits of and potential problems that might arise from using this real-time monitoring approach. Comments are also sought on alternative methods that could be employed to monitor the RF spectrum signal levels and to control the interference temperature.

45. By employing TPC and DFS and by permitting unlicensed operation at very modest power levels (as indicated above, we envision maximum unlicensed EIRPs possibly in the range of 30 dBm to

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[42] This result assumes that an unlicensed device receives a signal from the fixed station transmitter with approximately the same free space path loss as the signal path between the fixed station transmitter and receiver. Thus, assuming no variation in other propagation variables, the level of received power at the fixed receiver would be approximately equal to that measured by the unlicensed device with the addition of the gain of the fixed station antenna. That is, antenna off-axis attenuation (-32 dB) plus typical propagation loss (-89 dB) plus desired S/I (30 to 50 dB) produces an unlicensed margin overhead of 91 to 71 dB. We note that this value could be useful in determining the sensitivity of the DFS used with the unlicensed system and seek comment in that regard.

[43] Similarly, an antenna off-axis attenuation (-30 dB) plus typical propagation loss (-95 dB) plus desired S/I (30 to 50 dB) produces an unlicensed margin overhead of 95 to 75 dB. We note that this value could be useful in determining the sensitivity of the DFS used with the unlicensed system and seek comment in that regard.

[44] The method used to monitor the RF levels and the sensitivity of the monitoring system employed would directly impact how an unlicensed system would adjust its output frequency. Emission levels could be detected by individual unlicensed devices, which would then adjust their output frequencies based on the level of the detected RF emissions, or they could be detected by centralized control stations which would then cause the operating frequencies of their satellite stations to be adjusted.

[45] Note that the Commission proposed a shorter averaging duration for UNII devices.

36 dBm), we believe that sharing between unlicensed devices and these incumbent systems is feasible. We observe that these systems have been able to share in the past by conducting frequency coordination prior to operation. We believe that the use of TPC and DFS can automatically mimic this function, but in real time as opposed to manual human coordination activities. We further observe that the significant power difference between incumbent terrestrial systems and proposed unlicensed devices puts the unlicensed devices at considerably more risk of receiving interference than of causing interference. We request comment on these observations and seek proposals for appropriate technical criteria. Specifically, we seek comment on the proper detection thresholds that should apply for DFS. Should the threshold be referenced to the received power averaged over one millisecond referenced to a 0 dBi antenna? Or should some other reference be used? Detailed technical comments should be submitted to support commenters' positions. Comments also are requested on the bandwidth and time period over which we should require that the spectrum be monitored prior to operation. Also, commenters should provide details regarding how often the spectrum should be monitored after transmission begins. We also request comment whether the TPC capability should be required to reduce power by more than 6 dB below the maximum power? If so, to what level? What are the limits of current technology for TPC?

46. We request comment on these observations and seek proposals for appropriate technical criteria for operation in this band. Specifically, we seek comment on the proper detection thresholds that should apply for DFS. Should the threshold be referenced to the received power averaged over one millisecond referenced to a 0 dBi antenna? Or should some other reference be used? Detailed technical comments should be submitted to support commenters' positions. Comments also are requested on the bandwidth and time period over which we should require that the spectrum be monitored prior to operation. Also, commenters should provide details regarding how often the spectrum should be monitored after transmission begins. We also request comment whether the TPC capability should be required to reduce power by more than 6 dB below the maximum power? If so, to what level? What are the limits of current technology for TPC?

47. *General In-band Considerations*. We also seek comment on the general in-band technical requirements that would be appropriate for unlicensed operations in the 6525-6700 MHz and 12.75-13.25 GHz bands under an interference temperature paradigm. For example, Section 15.402 of the Rules sets forth various limits on the maximum transmit power, the maximum spectral power density, and other related technical limits for unlicensed network information infrastructure (U-NII) devices in various frequency bands.[46] In addition, these rules require systems using directional antennas with a gain greater than 6 dBi required to reduce both the maximum transmit power and the maximum power density. We have found those criteria to be effective, and seek comment on adopting similar technical requirements for unlicensed operations under our interference temperature rules in the 6525-6700 MHz and 12.75-13.25 GHz bands. In this regard, we again note that our initial analysis indicates that a reasonable interference temperature limit in this band might support unlicensed operations with maximum transmit powers possibly in the range of 24 dBm to 30 dBm and EIRPs in the range of 30 dBm to 36 dBm. We seek comment on the merit of this tentative conclusion. We also encourage commenters to suggest specific alternative technical limits and to include detailed supporting analysis. Such analysis should minimally include thorough link budget analyses along with discussions of the advantages and disadvantages of various options and alternatives.

48. We request comments on whether any portion of the bands discussed above that are allocated for fixed operation should be excluded from consideration under this proposal and why. For example, is it necessary to preclude unlicensed operation in the 6650-6675.2 MHz portion of this band to protect radio astronomy operations or can suitable technical standards be developed to ensure that harmful interference is not caused? Is it necessary to preclude unlicensed operation in the 13.15-13.2125 GHz band to protect mobile operations or are the proposed standards sufficient to ensure that mobile systems will not receive harmful interference from unlicensed operations?

[46] 47 C.F.R. § 15.402. U-NII devices operate on frequencies in the 5.15-5.825 GHz region of the spectrum.

49. *Out-of-band Emissions*. We recognize the need to assure that increased operation of unlicensed devices enabled under the interference temperature concept in these bands will not result in harmful out-of-band interference. To that end, we propose that such operations should comply with an undesirable emission limit such as that set forth in Section 15.407(b)(1) of the Rules. This rule requires that all out-of-band emissions from U-NII devices operating in the 5.15-5.25 GHz band not exceed an EIRP of -27 dBm/MHz. Our experience to date has shown that this limit has served well in the context of its current application to U-NII in this band. Based on that experience, we seek comment on whether a similar requirement will be beneficial when applied to the out-of-band emissions of unlicensed operations in the 6525-6700 MHz and 12.75-13.25 GHz bands. We request comment on whether the nature and value of the emission limit we propose herein would be appropriate. Commenters should discuss whether other out-of-band emission limits should be considered as well and whether additional limits should be specified immediately outside of the operating channel. For example, commenters might wish to address whether another single value limit, or alternatively, multiple value limits graduated by frequency offset would be more appropriate.

50. *Satellite Monitoring of Spectrum Occupancy.* The Inquiry describes a number of approaches to adaptive or real-time interference temperature measurement by which monitored information regarding spectrum occupancy could be transmitted back to individual devices. As an additional example, it could be possible for satellites to monitor and make available real-time measured data such as $\Delta T/T$, I/N, C/I, C/(I+N) and I that could then be used by individual devices to adjust their operation to ensure that they do not interfere with other licensed operations. This capability would appear to be feasible since satellites are already being used for real-time, remote monitoring of geophysical, meteorological and environmental conditions on the surface of the earth.

51. We request comment on the utility and potential benefits of such a real-time monitoring approach in the two bands discussed above, as well as in any other bands where the interference temperature concept could be applied. We request comment on how the monitored information could be acquired by unlicensed devices. For example, the information might be provided via broadcast signals (possibly through a subscription service) or other means. One possibility could be that unlicensed equipment operating in this manner would consist of systems controlled by centralized transmitting stations that relay this information. More generally, commenters should indicate whether they believe there is interest in such a system and specify how they envision such a system might work. We also request comment on the state of current technology and whether such a system is technically feasible today. If such a system were to exist, what data should be provided to unlicensed devices? Who should operate such a system?

## PROCEDURAL MATTERS

52. As required by the Regulatory Flexibility Act, see 5 U.S.C. § 603, the Commission has prepared an Initial Regulatory Flexibility Analysis (IRFA) of the possible significant economic impact on small entities of the proposals suggested in this document. The IRFA is set forth in Appendix A. Written public comments are requested on the IRFA. These comments must be filed in accordance with the same filing deadlines as comments filed in this Notice of Proposed Rule Making ("Notice"). Comments must have a separate and distinct heading designating them as responses to the IRFA.

53. This is a permit-but-disclose notice and comment rule making proceeding. *Ex parte* presentations are permitted, except during the Sunshine Agenda period. *See generally* 47 C.F.R. §§ 1.1200(a), 1.1203, and 1.1204(b).

54. Pursuant to Sections 1.415 or 1.419 of the Commission's rules, 47 C.F.R. §§ 1.415, 1.419, interested parties may file comments on before **75 days after publication in the Federal Register**, and reply comments on or before **105 days after publication in the Federal Register**. Comments may be

filed using the Commission's Electronic Comment Filing System (ECFS) or by filing paper copies. *See Electronic Filing of Documents in Rulemaking Proceedings*, 63 Fed. Reg. 24,121 (1998).

55. Comments filed through the ECFS can be sent as an electronic file via the Internet at <http://www.fcc.gov/e-file/ecfs.html>. Generally, only one copy of an electronic submission must be filed. If multiple docket or rulemaking numbers appear in the caption of this proceeding, however, commenters must transmit one electronic copy of the comments to each docket or rulemaking number referenced in the caption. In completing the transmittal screen, commenters should include their full name, Postal Service mailing address, and the applicable docket or rulemaking number. Parties may also submit an electronic comment by Internet e-mail. To get filing instructions for e-mail comments, commenters should send an e-mail to ecfs@fcc.gov, and should include the following words in the body of the message, "get form <your e-mail address>." A sample form and directions will be sent in reply.

56. Parties who choose to file by paper must file an original and four copies of each filing. If more than one docket or rulemaking number appears in the caption of this proceeding, commenters must submit two additional copies for each additional docket or rulemaking number. All filings must be sent to the Commission's Secretary, Marlene H. Dortch, Office of the Secretary, Federal Communications Commission, The Portals, 445 Twelfth Street, S.W., Washington, D.C. 20554.

57. Filings can be sent by hand or messenger delivery, by commercial overnight courier, or by first-class or overnight U.S. Postal Service mail (although we continue to experience delays in receiving U.S. Postal Service mail). The Commission's contractor, Natek, Inc., will receive hand-delivered or messenger-delivered paper filings for the Commission's Secretary at 236 Massachusetts Avenue, N.E., Suite 110, Washington, D.C. 20002. The filing hours at this location are 8:00 a.m. to 7:00 p.m. All hand deliveries must be held together with rubber bands or fasteners. Any envelopes must be disposed of before entering the building. Commercial overnight mail (other than U.S. Postal Service Express Mail and Priority Mail) must be sent to 9300 East Hampton Drive, Capitol Heights, MD 20743. U.S. Postal Service first-class mail, Express Mail, and Priority Mail should be addressed to 445 12th Street, S.W., Washington, D.C. 20554. All filings must be addressed to the Commission's Secretary, Marlene H. Dortch, Office of the Secretary, Federal Communications Commission.

58. Parties who choose to file by paper should also submit their comments on diskette. Such a submission should be on a 3.5-inch diskette formatted in an IBM compatible format using Microsoft Word or compatible software. The diskette should be accompanied by a cover letter and should be submitted in “read only” mode. The diskette should be clearly labeled with the commenter’s name, proceeding (including the lead docket number, type of pleading (comment or reply comment), date of submission, and the name of the electronic file on the diskette. The label should also include the following phrase "Disk Copy – Not an Original." Each diskette should contain only party’s pleading, preferably in a single electronic file. In addition, commenters must send diskette copies to the Commission’s copy contractor, Qualex International, Portals II, 445 12th Street, SW, Room CY-B402, Washington, DC, 20554.

59. Alternative formats (computer diskette, large print, audio cassette and Braille) are available to persons with disabilities by contacting Brian Millin at (202) 418-7426, TTY (202) 418-2555, or via e-mail to Brian.Millin@fcc.gov. This *Notice* can also be downloaded at http://www.fcc.gov/oet.

60. The proposed action is authorized under Sections 4(i), 301, 302, 303(e), 303(f), 303(r) and 307 of the Communications Act of 1934, as amended, 47 U.S.C. Sections 154(i), 301, 302, 303(e), 303(f), 303(r) and 307.

61. The Commission’s Consumer and Governmental Affairs Bureau, Reference Information Center, SHALL SEND a copy of this Notice, including the IRFA, to the Chief Counsel for Advocacy of the Small Business Administration.

62. For further information regarding this Notice of Inquiry and Notice of Proposed Rulemaking, contact Gary Thayer, Office of Engineering and Technology, (202) 418-2290, e-mail gary.thayer@fcc.gov, or John Reed, Office of Engineering and Technology, (202) 418-2455, e-mail john.reed@fcc.gov, or Ahmed Lahjouji, Office of Engineering and Technology, (202) 418-2061 e-mail ahmed.lahjouji@fcc.gov.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

## Appendix A

### Initial Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act,[47] the Commission has prepared this Initial Regulatory Flexibility Analysis (IRFA) of the possible significant economic impact on small entities by the policies and rules proposed in this Notice of Proposed Rule Making *("Notice")*. Written public comments are requested on the IRFA. Comments must be identified as responses to the IRFA and must be filed by the deadlines for comments on the Notice provided in paragraph 54 of this item. The Commission shall send a copy of this Notice, including the IRFA, to the Chief Counsel for Advocacy of the Small Business Administration. In addition, the Notice and the IRFA (or summaries thereof) will be published in the Federal Register.[48]

### A. Need for, and Objectives of, the Proposed Rules.

This rulemaking proposal is initiated to obtain comments regarding proposed changes to the regulations for radio frequency devices that do not require a license to operate. The Commission seeks to determine if its standards should be amended to permit the expanded operation of unlicensed devices in the 6525-6700 MHz and 12.75-13.25 GHz bands. We believe that it may be necessary to shift our current paradigm for assessing interference from approaches based primarily on transmitter operations towards new approaches that focus on the actual RF environment and interaction between transmitters and receivers, such as the interference temperature metric. In order to begin our exploration of the process that would be involved in a transition to an interference temperature regime, we seek comment on specific technical guidelines in the NPRM portion of our discussion that we believe can be implemented in the near future for selected frequency bands prior to any general implementation of interference temperature limits and real-time adaptation of transmitters to the interference temperature environment.

### B. Legal Basis.

The proposed action is taken pursuant to Sections 4(i), 301, 302, 303(e), 303(f), 303(r), and 307 of the Communications Act of 1934, as amended, 47 U.S.C. Sections 154(i), 301, 302, 303(e), 303(f), 303(r), and 307.

### C. Description and Estimate of the Number of Small Entities to Which the Proposed Rules Will Apply.

The RFA directs agencies to provide a description of, and where feasible, an estimate of the number of small entities that may be affected by the proposed rules, if adopted.[49] The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[50] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[51] A "small business concern" is one which: (1) is independently owned and operated; (2) is not dominant in its field of

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[47] *See* 5 U.S.C. § 603.

[48] 5 U.S.C. § 603(a).

[49] 5 U.S.C. § 603(b)(3).

[50] 5 U.S.C. § 601(6).

[51] 5 U.S.C. § 601(3) (incorporating by reference the definition of "small-business concern" in the Small Business Act, 15 U.S.C. § 632). Pursuant to 5 U.S.C. § 601(3), the statutory definition of a small business applies "unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register."

operation; and (3) satisfies any additional criteria established by the Small Business Administration (SBA).[52] Nationwide, there are approximately 22.4 million small businesses, total, according to the SBA data.[53]

A small organization is generally "any not-for-profit enterprise which is independently owned and operated and is not dominant in its field."[54] Nationwide, as of 1992, there were approximately 275,801 small organizations.[55] The term "small governmental jurisdiction" is defined as "governments of cities, towns, townships, villages, school districts, or special districts, with a population of less than fifty thousand."[56] As of 1997, there were about 87,453 governmental jurisdictions in the United States.[57] This number includes 39,044 county governments, municipalities, and townships, of which 37,546 (approximately 96.2%) have populations of fewer than 50,000, and of which 1,498 have populations of 50,000 or more. Thus, we estimate the number of small governmental jurisdictions overall to be 84,098 or fewer.

The SBA has developed a small business size standard for wireless firms within the two broad economic census categories of Paging[58] and Cellular and Other Wireless Telecommunications.[59] Under both SBA categories, a wireless business is small if it has 1,500 or fewer employees. For the census category of Paging, Census Bureau data for 1997 show that there were 1320 firms in this category, total, that operated for the entire year.[60] Of this total, 1303 firms had employment of 999 or fewer employees, and an additional 17 firms had employment of 1,000 employees or more.[61] Thus, under this category and associated small business size standard, the majority of firms can be considered small. For the census category Cellular and Other Wireless Telecommunications firms, Census Bureau data for 1997 show that there were 977 firms in this category, total, that operated for the entire year.[62] Of this total, 965 firms had employment of 999 or fewer employees, and an additional 12 firms had employment of 1,000 employees or more.[63] Thus, under this second category and size standard, the majority of firms can, again, be considered small.

The SBA has established a small business size standard for Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing. Under this standard, firms are considered small if they 750 or fewer employees.[64] Census Bureau data for 1997 indicate that, for that year, there

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52 5 U.S.C. § 632.

53 *See* SBA, *Programs and Services*, SBA Pamphlet No. CO-0028, at pg. 40 (July 2002).

54 5 U.S.C. § 601(4).

55 U.S. Department of Commerce, Bureau of the Census, 1992 Economic Census, Table 6 (special tabulation of data under contract to the Office of Advocacy of the U.S. Small Business Administration).

56 5 U.S.C. 601(5).

57 U.S. Census Bureau, Statistical Abstract of the United States: 2000, Section 9, pgs. 299-300, Tables 490 and 492.

58 13 CFR § 121.201, NAICS code 513321 (changed to 517211 in October 2002).

59 13 C.F.R. § 121.201, NAICS code 513322 (changed to 517212 in October 2002).

60 U.S. Census Bureau, 1997 Economic Census, Subject Series: Information, "Employment Size of Firms Subject to Federal Income Tax: 1997," Table 5, NAICS code 513321 (issued Oct. 2000).

61 *Id*. The census data do not provide a more precise estimate of the number of firms that have employment of 1,500 or fewer employees; the largest category provided is "Firms with 1,000 employees or more."

62 U.S. Census Bureau, 1997 Economic Census, Subject Series: Information, "Employment Size of Firms Subject to Federal Income Tax: 1997," Table 5, NAICS code 513322 (issued Oct. 2000).

63 *Id*. The census data do not provide a more precise estimate of the number of firms that have employment of 1,500 or fewer employees; the largest category provided is "Firms with 1,000 employees or more."

64 13 C.F.R. § 121.201, NAICS code 334220.

were a total of 1,215 establishments in this category.[65] Of those, there were 1,150 that had employment under 500, and an additional 37 that had employment of 500 to 999. Thus, under this size standard, the majority of establishments can be considered small.

*Satellite Telecommunications* The SBA has developed a small business size standard for Satellite Telecommunications Carriers, which consists of all such companies having $12.5 million or less in annual receipts.[66] In addition, a second SBA size standard for Other Telecommunications includes "facilities operationally connected with one or more terrestrial communications systems and capable of transmitting telecommunications to or receiving telecommunications from satellite systems,"[67] and also has a size standard of annual receipts of $12.5 million or less. According to Census Bureau data for 1997, there were 324 firms in the category Satellite Telecommunications, total, that operated for the entire year.[68] Of this total, 273 firms had annual receipts of $5 million to $9,999,999 and an additional 24 firms had annual receipts of $10 million to $24,999,990.[69] Thus, under this size standard, the majority of firms can be considered small. In addition, according to Census Bureau data for 1997, there were 439 firms in the category Satellite Telecommunications, total, that operated for the entire year.[70] Of this total, 424 firms had annual receipts of $5 million to $9,999,999 and an additional 6 firms had annual receipts of $10 million to $24,999,990.[71] Thus, under this second size standard, the majority of firms can be considered small.

As no party currently is permitted to market or operate equipment under the proposed standards, there will be no immediate impact on any small entities. The Commission does not have an estimated number for the small entities that may currently be capable of producing such products but believes that there are only a few in existence.

**D. Description of Projected Reporting, Recordkeeping and Other Compliance Requirements for Small Entities.**

Part 15 transmitters are already required to be authorized under the Commission's certification procedure as a prerequisite to marketing and importation. The reporting and recordkeeping requirements associated with these equipment authorizations would not be changed by the proposals contained in this *Notice*. These changes to the regulations would permit the introduction of an entirely new category of radio transmitters.

**E. Steps Taken to Minimize the Significant Economic Impact on Small Entities, and Significant Alternatives Considered.**

The RFA requires an agency to describe any significant, specifically small business, alternatives that it has considered in reaching its proposed approach, which may include the following four alternatives (among others): "(1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; (2) the clarification,

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65 U.S. Census Bureau, 1977 Economic Census, Industry Series: Manufacturing, "Industry Statistics by Employment Size," Table 4, NAICS code 334220 (issued August 1999).

66 13 C.F. R. § 121.201, North American Industry Classification System (NAICS) code 517410 (formerly 513340).

67 *Id*. NAICS code 517910 (formerly 513390).

68 U.S. Census Bureau, 1997 Economic Census, Subject Series: Information, "Receipt Size of Firms Subject to Federal Income Tax: 1997," Table 4, NAICS code 517410 (issued Oct. 2000).

69 *Id*.

70 U.S. Census Bureau, 1997 Economic Census, Subject Series: Information, "Receipt Size of Firms Subject to Federal Income Tax: 1997," Table 4, NAICS code 517910 (issued Oct. 2000).

71 *Id*.

consolidation, or simplification of compliance and reporting requirements under the rule for such small entities; (3) the use of performance rather than design standards; and (4) an exemption from coverage of the rule, or any part thereof, for such small entities."[72]

As noted, in order to begin our exploration of the process that would be involved in a transition to an interference temperature regime, we seek comment on specific technical guidelines in the NPRM portion of our discussion that we believe can be implemented in the near future for selected frequency bands prior to any general implementation of interference temperature limits and real-time adaptation of transmitters to the interference temperature environment. Currently, no party is permitted to market or operate equipment under the proposed standards, so there will be no immediate impact on any small entities. One alternative to our proposal is reflected in our request for comments on whether it is necessary to preclude expanded unlicensed operation in the 650-6675.2 MHz band to protect radio astronomy operations or whether suitable technical standards can be developed to ensure that interference is not caused. We invite small entities to comment on this alternative.

**F. Federal Rules that May Duplicate, Overlap, or Conflict with the Proposed Rule.**

None.

[72] 5 U.S.C. § 603(c)(1) – (c)(4).

## Appendix B

### Satellite Link Budget Analyses

This appendix illustrates sample link budget analyses that suggest the approximate potential number of unlicensed devices that could be permitted to operate simultaneously within CONUS without causing harmful interference to the incumbent satellite systems.

We made the following assumptions for the purpose of simplification in order to roughly characterize hypothetical unlicensed operations in the band.

- 10% duty cycle for mobile unlicensed devices, *i.e.,* Wireless-LAN-based devices with a 30 dBm (1 W) maximum EIRP;
- 100% duty cycle for fixed systems with up to a 36 dBm (4 W) maximum EIRP;
- Equal number of devices operating indoors and outdoors;
- 10 dB signal attenuation to account for indoor signal loss;[73]
- Omnidirectional antenna for mobile devices, *i.e.*, attenuation in the direction of the satellite is, on average, 6 dB lower than the main signal;
- Directional antennas for fixed devices that provide, on average, attenuation of 22 dB relative to the main lobe in the direction of the satellite;[74] at angles ranging between 30 and 100-degrees off-axis from the transmission centerline; and
- Satellite interference threshold criterion, $\Delta T/T$, of 5%.[75]

The spectral power distribution of unlicensed emission levels was hypothesized according to Table 1.

[73] We recognize that the signal loss due to building attenuation at 12.75-13.25 GHz should be considerably higher than 10 dB. However, we wish to approach this expansion of unlicensed devices conservatively.

[74] This assumes that, in general, fixed transmitters do not point at the geostationary arc and instead point at receivers that are relatively close in height. Further, this assumes the use of a class B antenna which attenuates signals at angles between 30 and 100 degrees off-axis from the transmission centerline by at least 32 dB. It is likely that emissions at these angles will be in the direction of the geostationary arc. We note however that to be conservative in our analysis, we assumed an attenuation of only 21 dB.

[75] The interference threshold $\Delta T/T$ is a measure of the amount of interference that can be tolerated by the satellite system. $\Delta T/T$ is related to the increase in system noise temperature. $\Delta T/T$ corresponds to the interference-to-noise ratio, I/N (*e.g.*, 10 log ($\Delta T/T$ = 0.05 (5%)) = -13.01 dB). Coordination is required for a $\Delta T/T$ greater or equal to 6%. Our conservative analysis is based on a $\Delta T/T$ threshold equal to 5 %.

Using the 5% $\Delta T/Ts$ interference criterion, the allowable increase in the equivalent satellite link noise temperature, due to external interference sources, is calculated, for the values of Ts = 248 K ( or 23.94 dB-K), and Ts = 2076 K (or 33.17 dB-K), as follows:

Given a $\Delta T/Ts$= I/N, where Ts: equivalent satellite link noise temperature, and $\Delta T$: allowable increase in Ts.

For the Ext. C band, Ts = 248 K, and $\Delta T = (\Delta T/Ts)*Ts = 0.05 * 248 = 12.41$ K or 10.93 dB-K

For the Ext. Ku band, Ts = 2076 K, and $\Delta T = (\Delta T/Ts)*Ts = 0.05 * 2076 = 103.82$ K or 20.16 dB-K

Accordingly, the aggregate interference noise temperature power from all unlicensed devices in either of these bands must be 13.01dB below the corresponding equivalent satellite link noise temperature. Refer to the link budget table for information on how these parameters are used to calculate the maximum number of unlicensed devices that can operate within CONUS at the acceptable interference temperature threshold.

**Table 1. Unlicensed devices Power distribution**

| | Mobile Devices 10% Duty Cycle | | | | Fixed Devices 100 % Duty Cycle | |
|---|---|---|---|---|---|---|
| **EIRP (mw)** | 50 | 100 | 200 | 1000 | 2000 | 4000 |
| **Device Distribution %** | 30 | 35 | 20 | 5 | 5 | 5 |
| **% simultaneous transmissions at specified EIRP** | 3.0 | 3.5 | 2.0 | 0.5 | 5 | 5 |

The following sample link budget analyses are based on the assumptions above.

| Item | Units | Ext. C | Ext. Ku |
|---|---|---|---|
| | | | |
| Uplink Frequency Band | GHz | 6.613 | 13 |
| Lower Band limits | MHz | 6525 | 12750 |
| Upper Band limits | MHz | 6700 | 13250 |
| Wavelength | m | 0.05 | 0.02 |
| Effective Area Isotrope | dBm^2 | -37.9 | -43.7 |
| | | | |
| FSS System Parameters | | | |
| Percent of CONUS in one beam | % | 75 | 100 |
| FSS Satellite Uplink Antenna Gain | dBi | 32.3 | 31.1 |
| Typical Satellite Receive Temperature | K | 500 | 625 |
| FSS Satellite Transmission Gain | dB | -5.0 | 5.0 |
| Typical Earth Station Receive Temperature | K | 90.0 | 100.0 |
| Equivalent Satellite Link Noise Temperature | K | 248 | 2076 |
| | | | |
| Allowable Part 15 Device (Delta T/T) | % | 5.0 | 5.0 |
| | | | |
| Satellite System Parameters | | | |
| Allowable Increase in Eq. Sat. Link Noise Temp | K | 12.41 | 103.82 |
| FSS Satellite Transmission Gain | dB | -5.0 | 5.0 |
| Allowable Increase in Sat. Noise Temp | K | 39.2 | 32.8 |
| Boltzman Constant | dBW/Hz K | -228.6 | -228.6 |
| Allowable Interference Pwr @ Output of Sat. Ant. | dBW/Hz | -212.7 | -213.4 |
| FSS Satellite Uplink Antenna Gain | dBi | 32.3 | 31.1 |
| Nominal Free Space Loss | dB | -200..3 | -206.1 |
| Allowable Interference at Earth Surface | dBW/Hz | -44.7 | -38.4 |
| | | | |
| Interference Temperature System Parameters | | | |
| Transmit EIRPs from Aggregate Interfering Devices | dBW | -24.08 | -24.08 |
| Assumed Transmit Bandwidth | kHz | 20000 | 20000 |
| Part 15 Gain toward Sat | dBi | 0.0 | 0.0 |
| Part 15 Power density toward Sat | dBW/Hz | -97.1 | -97.1 |
| | | | |
| Allowable Interference at Earth Surface | dBW/Hz | -44.7 | -38.4 |
| Part 15 Power density toward Sat | dBW/Hz | -97.1 | -97.1 |
| Allowable Emitters per Beam in RLAN BW | dB | 52.3 | 58.7 |
| Allowable Emitters per Beam in RLAN BW | # | 171544 | 739832 |
| | | | |
| Allowable Emitters | | | |
| Allowable number of emitters/satellite beam | # | 171544 | 739832 |
| Available Bandwidth per satellite beam | MHz | 175 | 500 |
| Part 15 Reuse Bandwidths in FSS Band | MHz | 11.67 | 25.00 |
| Alternate Polarizations | # | 2 | 2 |
| **Total number of unlicensed systems within CONUS** | | **53,369,095** | **369,916,129** |

## SEPARATE STATEMENT OF CHAIRMAN MICHAEL K. POWELL

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

The introduction of a new "interference temperature" model has the potential to tremendously improve radio spectrum management. Rather than assess interference based solely on transmitter operations, the interference temperature model introduced in the Commission's Spectrum Policy Task Force Report takes into account the cumulative effects of all undesired radio frequency energy. The marketplace demands for spectrum require that we explore new ways to use this resource more efficiently.

The Notice of Inquiry seeks comment on various technological factors and the process for managing the transition to a new interference temperature paradigm. The Notice of Proposed Rulemaking seeks comments on technical rules that would establish proper limits and procedures for assessing interference temperature. Moreover, the NPRM proposes to begin experimenting with the interference temperature approach on a limited basis in select frequency bands and recommends imposing restrictions on unlicensed devices that would include limiting the transmitter output power and requirements to use transmit power control (TPC) and dynamic frequency selection (DFS).

I fully support consideration of this new approach to interference control and spectrum management. It promises to promote more efficient use of spectrum and encourage new and innovative uses of this important resource for the benefit of the American public.

## SEPARATE STATEMENT OF
## COMMISSIONER MICHAEL J. COPPS

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

I'm excited to see the beginning of the examination of whether we can put the spectrum temperature concept into practice. As I've said before, I think that the idea has great promise, if we use it as a tool to increase the efficiency with which spectrum resources are put to use, as is our statutory responsibility.

I hope that commenters will use the NOI to address an issue that is of particular concern to me. While the interference temperature metric may be a good new way to measure interference, we do not have an adequate way to determine what the right interference temperature is for a given band. The only tools we have for this job are the ill-fitting and ill-defined "interference" and "harmful interference" concepts. The inappropriateness and inadequacy of these concepts for the job of prospectively setting interference temperature will make this new metric very hard to use predictably and non-arbitrarily in the real world.

So I think that the Commission must work to improve the standard we use to determine permissible levels of interference, whether using the interference temperature metric or some other metric. And I believe that an important side benefit of the added predictability that a better standard would bring is that incumbent spectrum users would be more comfortable with the interference temperature metric. This NOI is the perfect vehicle to start the process.

**SEPARATE STATEMENT OF**
**COMMISSIONER JONATHAN S. ADELSTEIN**
**APPROVING IN PART, CONCURRING IN PART**

*Re: In re Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed operation in the Fixed, Mobile and Satellite Frequency Bands; ET Docket No. 03-237*

I commend the Spectrum Policy Task Force and its members for their 2002 report and for bringing to the Commission's attention a new interference temperature approach to spectrum management. The Task Force noted that the "increasing demand for spectrum-based services and devices are straining longstanding, and outmoded, spectrum policies." I could not agree more. The reality is that we cannot produce more spectrum. We need to foster a framework for innovation that enables new technologies to come forward to meet demand more efficiently – in both the private and public sectors.

Most significantly, the Task Force report offered specific findings and recommendations that have been very useful in stimulating debate in the area of spectrum management. The concept of interference temperature is a particularly significant recommendation, and I very much look forward to a full and vigorous discussion on this challenging issue. I recognize that this is one of the more controversial proposals to come out of the report, but believe that it is entirely appropriate for the Commission to seek comment on new approaches to spectrum management. Whatever the outcome, the deliberation process makes us a better, more informed agency, and I encourage all interested parties to file comments in this proceeding.

I have previously noted my belief that the Commission should strive to push the boundaries to accommodate new technologies provided that they do not cause harmful interference. Indeed, a little noticed provision of the Communications Act, Section 157, reads that "It shall be the policy of the United States to encourage the provision of new technologies and services to the public." If an interference temperature model for quantifying and managing interference can be developed so that it truly prevents real harmful interference and allows for the provision of new technologies and services, then we should encourage its development. I do not know if we are there yet, but I very much look forward to the debate.

Finally, while I support the discussion in the item considering the application of the interference temperature approach to unlicensed operations in the 6525-6700 MHz and 12.75-13.25 GHz bands, I do not believe that this portion of the item should be styled as a Notice of Proposed Rule Making, as opposed to remaining part of the Notice of Inquiry. I think it is very clear that we are exploring an entirely new concept in the interference temperature model, and it is quite premature to actually discuss proposed rules when the Commission has not even engaged in a preliminary discussion on the interference temperature approach as a whole.

I am not sure what the rush is and am not convinced that moving this discussion to the NOI portion of the item somehow holds back our consideration of the interference temperature approach. I think the licensees in these bands deserve better. For this reason, I can only concur to the NPRM portion of this item.