BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

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

COMMENTS BY HYPRES, INC.

MARCH 5, 2004

HYPRES, Inc. is submitting these comments in response to the solicitation for information in the NOI and NPRM adopted November 13, 2003.

HYPRES, Inc. is a manufacturer of exceptionally high-performance and cost-effective electronic equipment using Superconductor MicroElectronics (SME) technology. HYPRES has demonstrated digital circuit capabilities that far exceed the performance currently available and forecasted with semiconductors and other implementations. The performance of SME circuits enables real-time processing of RF signals in the digital domain with unprecedented accuracy and speed at frequencies previously unattainable. HYPRES technology brings the power of digital processing to the RF domain. The technology is so accurate it defines the volt; so sensitive it can measure brain currents, and so fast that it can directly convert RF signals.

In these comments HYPRES responds to some of the questions asked in the NOI/NPRM, and indicates areas where the performance SME technology can make a substantial contribution to effective implementation of Commission Policy using the Interference Temperature metric. We also indicate some approaches to spectrum monitoring and data collection to enhance the utility of Interference Temperature measurement for decision making.

General Comment

The Commission is faced with the challenge of meeting demands for spectrum, regulating spectrum use, and recognizing changes introduced by advances in technology. The Spectrum Policy Task Force Report[1] recommends a change in emphasis away from transmitter specifications as the basis for spectrum management to a more flexible, holistic and dynamic approach based on recognition of actual field conditions present at a specific place, time, and segment of the RF spectrum. HYPRES is strongly supportive of this concept.

The SPTF recommended "interference temperature" (IT) as a measure of ambient RF energy. They also recommended it as a means for more effective spectrum allocation – in specified services a transmitting station could transmit if its contribution to the ambient IT did not exceed a predetermined level.

Interference temperature is one of several means of measuring local RF energy. Flux density, power, SNR, noise figure, and Eb/No all provide information about the absolute energy level or the relative strength of the signal of interest over other impinging RF energy. There is a degree of ambiguity in the use of the term as to whether a given IT value means all of local RF energy or the level of interference to a specific signal.

The concept advanced by the Spectrum Policy Task Force of using IT for dynamic spectrum allocation is an intriguing, but different, concept from IT as an energy metric. Under a specific set of circumstances, a station wishing to transmit would look for a portion of spectrum where it could do so without exceeding established temperature limits. This process is essentially a means for dynamic spectrum allocation based on local decision making rather than administrative process.

For conceptual clarity, HYPRES suggests the following definitions that make these differences clear:

> **Interference Temperature (IT).** The RF power generated by undesired emitters plus noise sources that are present in a receiver system (I + N) per unit bandwidth, measured in degrees Kelvin (K).[2] The equivalent power level is the denominator of SNR.
>
> **Signal Strength**. The RF power of a signal of interest. It is the power level of a transmitter measured at a specific location, and the numerator of SNR.
>
> **Temperature-based Spectrum Availability (TSA).** A decision-making process for determining whether a specific channel can accommodate a proposed emission. First a local IT limit must be in place. Then, prior to transmitting, the prevailing IT is measured at that location and an estimate made of the total temperature that will be observed if the intended transmission takes place. The

[1] Spectrum Policy Task Force Report, ET Docket No. 02- 135, November 2002
[2] NOI/NPRM, FCC Docket 03-289, Par. 10.

transmission may proceed if it does not result in a local temperature exceeding the designated limit.

The Spectrum Policy Task force Report also identifies the present predominant regulatory model of the Commission as "Command and Control,"[3] and identifies two other models, "Commons" and "Exclusive Right." Application of IT and TSA will have significant differences under these models.

HYPRES, therefore, recommends that the Commission promote an architectural structure, such as that recommended by the SPTF, within which the TSA concept can be investigated and implemented as a means to improve the efficiency of spectrum utilization. We also recommend that the Commission make clear to current participants in radio services the level of their exposure to any change in regulatory approach in order to avoid unnecessary opposition to the plans.

IT, of course, as a metric applies to all spectrum. We recommend that the term "interference temperature" not be used imprecisely to refer to what we have called TSA, the process of determining spectrum availability based on the IT metric.

Spectrum Monitoring

The holistic approach to spectrum management advocated by the SPTF report requires more knowledge about spectrum utilization in frequency, space, power, and time than is currently available. It also suggests noise temperature as a local variable that can be used to improve spectrum efficiency. One approach to filling the need for data is a monitoring network. The performance of HYPRES technology opens significant new possibilities for spectrum monitoring.

In the process of building out network coverage, the wireless service providers have established antenna sites all over the United States. Those sites have a significant potential to play a remote sensor role both within and outside bands that are in operation from those sites. Spectrum monitoring can improve understanding of how spectrum is being utilized, and to improve security by alerting the proper authorities when rule violations are occurring.

HYPRES technology provides high-performance correlation-based receivers that can provide the following services. They can be an additional product offering by Service Providers, providing useful services to the government and other customers, and additional revenue to the operators.

Baseline Spectrum Usage Determination. With a high performance front end, base station receivers can sample a wide range the ambient RF environment on a routine basis. Operating as a background task behind the primary mission of supporting wireless

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[3] SPTF Report, Pg. 5

service, the base station receiver can take systematic samples of the spectrum at specific frequencies and times to determine what emitters are active, and the power level received. The resultant data point will provide information about the receiver location, sector direction, frequency observed, time of the sample, and information about the received signal. It is also possible to synchronize sampling across a group of base stations so that simultaneous data points are available for subsequent investigations of interference or over-temperature conditions . The sampling rate and duration can be varied to control the volume of data generated and the precision of coverage. Over a period of time the accumulated data will provide the state of the spectrum (SoS), a comprehensive picture of spectrum usage in the geography covered by the monitoring facilities.

ONGOING IT MEASUREMENT AND RECORDING. After a baseline model of the RF spectrum at a given location is established, it can be compared to current conditions to identify anomalies and to forecast changes from introducing new services and emitters. Using statistical sampling techniques, the monitor looks for high levels of usage on normally low utilization channels or sudden activity where there are no known emitters. Such anomalies can be an early indicator of an emergency or other activity that warrants attention. The data gathered is also used to update the baseline model to reflect introduction of new services.

GENERATE SPECTRUM ALERTS. With a baseline model and monitoring capability it is possible to identify events that are not statistically consistent with the normal case. The presence of an unusual emission or absence of an expected one can trigger an alert. A faulty x-ray machine might trigger such an alert, as might a broadcast station going off the air. The mechanism would be band and service conscious so that normally sporadic signals, such as police radar, would not be seen as an abnormal event. This kind of monitoring could become a service, where notification of the presence or absence of a specific signal is offered as a service to a subscriber. Interference with a specific service could also be reported.

HYPRES recommends that the Commission start a program to explore the feasibility of using existing infrastructure networks to take on an added monitoring and recording role to support new approaches to spectrum management based on IT and TSA. HYPRES further recommends that work be initiated to standardize record keeping and file formats for monitoring systems to facilitate information exchange.

Spectrum Segment Management

Spectrum can be managed by strict control of emitters, by turning control of specified frequency bands over to operators, or by open contention. The SPTF report asserts that a substantial portion of the spectrum at any point in time is "white space", parts of the spectrum that are unused, and makes a number of recommendations for its use.[4]

Being a six dimensional construct (x, y, z, time, frequency, temperature), white space is difficult to deal with. Each of the spectrum management techniques has a different trade-off between probability of a successful connection and optimization of spectrum use.

A minute of white space is information transfer opportunity lost forever. Use of local interference temperature as the basis for spectrum allocation has a potential to convert vast amounts of white space to useful data transmission capacity. Two things are needed to realize this potential. One is a dynamic means of spectrum allocation. The other is a mechanism for recognizing and correcting collisions when they occur. We address the spectrum allocation in this section, and corrective action in the following section, Interference Mitigation.

In the previous section we discussed spectrum monitoring. Here we suggest building on that capability by establishing the concept of a local Spectrum Segment Manager (SSM). This entity will have real-time access to the historical baseline information and current data for a given portion of spectrum in a defined geography. A "segment" is analogous to a telephone call, a given channel frequency under the purview of a Spectrum Segment Manager in a specified geographic area allocated for a period of time that to fulfill a specific request for communication.

In order for a wireless communication to take place, a transmitter and a receiver within radio range need to be tuned to a specific channel frequency. The operating concept of SSM is similar to that of a trunked radio system: at the time a station wants to initiate communication the originator and called party are assigned a channel, switch their equipment to that channel, and proceed to transfer data. Several radios can be assigned to a specific trunk group, and will participate in any call. Similarly, a given radio can be assigned to multiple groups, although only one can be active at a time.

Traditional trunked radio systems involve a few tens of frequencies dedicated to a local or state government. At any given time, the Police, Department of Public Works, or other city department might use a specific frequency. But because they do not all need access all the time, a large number of trunk groups can share a much smaller number of channels. Occasionally all frequencies will be in use, and a request is denied. When not communicating, all of the radios monitor a common channel waiting for a call to come through.

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[4] SPTF Report, Pgs. 3,10,14,47

SSM is that model scaled up. A large number of frequencies are assigned to a Manager. The monitoring network provides information about the temperature of each frequency at a specific monitoring location. When a station want to communicate it notifies the Manager, giving information about the called party, bandwidth needed, and anticipated duration of the communication in seconds.

Upon receiving a request, the Manager finds the location of the called party or parties, analyzes the geographic relationship between the parties, and looks for a frequency with temperature headroom that can fulfill the needs. There are potentially a vast number of candidate channels for a given segment request. An analysis of the geography may indicate, for example, that the requested communication is not within the antenna geometry of any microwave links, so a fixed service channel can be used.

When a channel is found, it is allocated for the requested duration, and the frequency agile stations move to it. The calling party can request renewal of the assignment if needed prior to expiration of the current allocation.

Operation of such a system requires control, or signaling as it is called in the telephone world. Many of the stations participating are at fixed locations, so they each have an IP address, and communicate with Internet connections. Mobile stations are also addressed by their IP address, but they are connected through the control channel of a local wireless service provider. This is another product for the wireless company, who is paid on a per-call basis.

Adoption of a plan such as this has the advantage that there is no impact on existing equipment or services. They continue to operate as they have been. New equipment, however, can take advantage of the spectrum segment concept to fit into white space that would otherwise have gone unused.

HYPRES recommends consideration of a spectrum segment management system such as this, and the generation of system specifications so that future build-out can be done with the equipment having the performance and capabilities needed to make it function.

Interference Mitigation

With the monitoring and segment management facilities described above in place, the facilities necessary to identify and remove unauthorized emitters or sources of interference is in place. Receivers in operation on any service can monitor their signal to noise ratio. When a problem is observed, the receiver can make note of its characteristics, such as start and stop time. An interference report can be filed with the spectrum manager, who has data from both the monitoring system and SSM available to make tentative identification, and initiate ad-hoc monitoring to confirm the source.

A logging requirement can also be placed on transmitters. When an over-temperature or interference condition is recognized, the local manager can send out a general request for transmitters who were emitting on that frequency at the specified time to report their activity. Then an analysis can be made of the results to determine whether the observed conditions were the result of miscalculation, unexpected propagation, or inappropriate operation.

HYPRES recommends that requirements on radio station architecture be developed to support detection and identification of interfering emitters.

Incentives to Change

There are several hurdles in the path of adoption of IT as a measurement, and TSA as a technique for dynamic spectrum management. One problem is the performance constraints imposed on current infrastructure by the limitations inherent in semiconductor technology in digital processing of signals at radio frequencies. Another concern is the reluctance of equipment suppliers to adopt new and untried techniques when the comfort level is much higher with existing mature approaches. HYPRES would like to propose an approach to these related problems.

HYPRES is strongly supportive of the position expressed by Commissioner Adelstein in his separate statement attached to the NOI-NPRM. He says:

> 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."

HYPRES's SME technology as described in the Section "HYPRES Capabilities" (Attachment) provides a step-function improvement in performance of Digital RF circuits. Equipment using SME technology exhibits improvement in many of the operating parameters of radio equipment, including low noise, high receiver sensitivity, clean transmissions, and rapid response to changes in signal characteristics. These capabilities facilitate measurement of local IT and application of TSO decision making in real time. So, in addition to a number of benefits resulting from greatly enhanced radio performance, SME facilitates the procedures required to make full use of the advantages offered by IT concepts.

Overcoming industry inertia to change, however, requires other approaches to motivate the market to accept these new ideas. The fundamental requirement is for economic incentives to offset the cost involved in implementing them. Incentives are needed to provide real dollar returns, either initially or over the equipment life cycle, to compensate for the cost of implementation. Some cost reduction will be realized by reduction in dropped calls, fewer hand-offs, and increased effective system capacity. Other incentives, such as access to additional spectrum, rebate on license cost, or relief from certain regulatory restrictions, are incentives in the domain of the Commission. We recommend their consideration as a means to incentivize participants.

Conclusion

HYPRES is confident that its technology, as part of the emerging hardware and software performance improvements, will support Commission goals of spectrum policy revision, and introduction of both interference temperature measurement and temperature-based spectrum availability. We urge the Commission to take the increased performance available with SME into account when consideriing proposed rules. We also recommend exploration of incentives to operating with enhanced infrastructure performance.

We appreciate the opportunity to comment on the Interference Temperature NOI/NPRM.

Respectfully submitted,

Jack Rosa
CEO and President
Vice Chairman, Board Of Directors
HYPRES, Inc. **January 15, 2004**

ATTACHMENT

HYPRES Capabilities

HYPRES SME technology is ideally suited to support the proposed emergence of TSA based on IT measurement: Its exceptional performance provides exceptionally pure transmissions, ultra sensitive reception, and substantial processing power to support both normal radio operations and to provide effective monitoring capability. It provides unparalleled performance improvements in the digital domain allowing, for the first time, the direct digital conversion of RF signals while enabling the use of advanced ultra-high speed digital signal processing techniques. SME makes it possible to take the receive (or transmit) signal directly at the output of the base station antenna and directly convert (ADC) it into the digital format for further processing. The ultra low noise, high speed and sensitivity of the HYPRES Digital-RF allows spectrally pure frequency conversion and signal demodulation. Our technology affords many, hereto for unobtainable, benefits that can significantly improve the performance and cost of commercial wireless networks and base stations.

Performance degradations caused by thermal and spurious noise generated by analog frequency converters are eliminated. The Digital-RF front end contributes virtually no noise or signal distortion to the incoming signal. This low noise feature and the significantly enhanced sensitivity of Digital-RF translates to expanded regions for higher data rates and soft handoff, and substantially greater base station range and separation. These unique features result in enhanced network optimization and increased capacity (number of users and data rates/cell).

Digital processing in the RF domain enables (for the first time) use of optimum digital correlation techniques to increase S/(N+I) performance (typically 30dB or more) by providing interference and thermal noise suppression. This enables an increase in bandwidth utilization & user data rates while further reducing antenna size and High Power Amplifier (HPA) performance requirements. The HYPRES transceiver is capable of simultaneous reception and decoding of multiple signals over an ultras-broad frequency band. HYPRES hardware is not specific to any analog/digital modulation or multiple access schemes.

High speed digital processing directly at the transmit frequencies enables the direct linearization of the multi-GHz waveform at the HPA input by using broadband RF pre-distortion to dynamically correct all distortions in near real time. This enables multi-carrier operation via a single HPA while simultaneously optimizing in-band performance and minimizing out-of-band spurious effects far beyond what current (or forecasted) technologies can achieve. This also represents a significant reduction in initial and operating cost, due to much higher HPA efficiencies, reducing HPA cost by 50% to 75%. Unique features in antenna optimization provide the ability to balance the forward (transmit) and reverse (receive) links without an increase in antenna size.

The following are detailed characterizations of HYPRES SME capabilities:

Simultaneous wideband and high-fidelity digitization — Capability of producing 14 to 24 effective (true) bits with 100 to 160 dB Spur Free Dynamic Range (SFDR) over the 100 kHz to 2 GHz range (a 20,000 to 1 bandwidth).

Ultra-high Analog to Digital Converter (ADC) resolution — Capability of producing over 20 effective (true) bits with an SFDR exceeding 130 dB for 3G/4G bandwidths (60 to 100 MHz) at 2 GHz level carrier frequencies.

Extremely Low-noise, High-sensitivity, and ultra low Bit Error Rate (BER)— Noise-free digital RF front-ends (< 1^{o} K noise temperature) with sensitivities of -140 to -180 dbm and Bit Error Rates (BER) less than 10^{-15}.

Spectrally-pure carriers –HYPRES high stability multi-GHz clocks coupled with our inherently-perfect Digital to Analog Converters (DAC) provide spectrally-pure GHz-frequency carriers for transmission via a single or multiple high-power amplifiers (HPA).

Ultra-Linearized Single HPA – Capability to directly synthesize digitally pre-distorted wideband waveforms for transmission, enabling multi-carrier operation via a single HPA, simultaneously optimizing in-band performance and minimizing out-of-band spurious effects.

Low-power Tera-OPS DSP – Execution of Digital Signal Processing operations at clock speeds greater than 100 GHz, including picosecond RAM/ROM access operations and programmable digital filtering, while dissipating only 1 mW/chip.

Ultra-high Reliability & Durability – Similarly packaged products currently deployed in wireless communication base-station receivers have logged over a million failure-free hours.

Compatibility with Existing Systems – Although revolutionary in operation, HYPRES Digital RF products can occupy existing 19 in. racks and interface to any standard bus configuration at a maximum speed limited only by bus performance.

HYPRES modules are now being designed into the next generation of military systems. Development of system architectures to support the introduction of TSA can plan on product availability with the system performance levels described above.