BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C.

In the Matter of	)	
	)	
Promoting Efficient Use of Spectrum Through	)	WT Docket No. 00-230
Elimination of Barriers to the Development of	)	
Secondary Markets	)	
	)	
	)	

COMMENTS BY HYPRES, Inc

Introduction: HYPRES Technology

HYPRES, a member of the SDR Forum, is submitting these comments in response to this Notice of Proposed Rule Making (NPRM).

HYPRES has demonstrated the basic technology needed to produce the following characteristics:

Simultaneous wideband and high-fidelity digitization — Capability of producing 14 to 24 effective (true) bits with better than 100 to 160 dB 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 a spur-free dynamic range exceeding 130 dB for 3G/4G bandwidths (60 to 100 MHz) at 2 GHz level carrier frequencies.

Extremely Low-noise, ultra high-sensitivity, and ultra low Bit Error Rate (BER)— Virtually no-noise digital RF front-end ($< 1^{o}$ K) and orders of magnitude better sensitivities of -140 to -180 dbm with BERs less than 10^{-15}.

Spectrally-pure carriers –HYPRES 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 power amplifiers.

Ultra low-power Tera-OPS DSP — Digital Signal Processing at clock speeds greater than 100 GHz, including picosecond RAM/ROM operation and programmable digital filtering, dissipating only 1 mW/chip. This performance enables applications such as spectrum monitoring and predistortion of signals for HPA linearization. Example:
FFT performance –a 1024-point FFT can be performed at sub-microsecond speeds with a device dissipating less than 50 mW. This performance enables data rates exceeding 20 Mbps making modulation techniques such as 256 QAM and OFDM practical. It also reduces overhead due to error correction and packet retransmission.

Multi-carrier operation — Capability of producing spur-free broadband multi-carrier operation. Our DACs and digital signal processors (DSP) have the capability to synthesize digitally pre-distorted wideband waveforms for transmission via a single high performance power amplifier (HPA), simultaneously optimizing in-band performance and minimizing out-of-band spurious effects. The combination of DAC and DSP functions make a variety of high-performance application feasible.

Ultra high reliability – On the order of 1 million failure-free hours have already been logged by similarly packaged products deployed in wireless communication base-station receivers.

HYPRES technology offers the following benefits to operators of wireless networks and the FCC:

Lower Capitalization per Base Station — One digital radio performs the tasks of many conventional protocol-and frequency-specific base station radios. For example, the critical communication equipment is reduced to about 10% of a traditional GSM base station. This also creates a single universal platform that can be configured dynamically and/or periodically (in the factory or in the field) to suit different services, regardless of communication bandwidth or standard. This significantly reduces the cost of base stations and the infrastructure provider's capital equipment inventory needed to accommodate multiple protocols.

Significantly Reduced Network Capital Expenditures *&* **Operating Expenses** — HYPRES technology enables the significant expansion of base station range coverage, enabling a significant reduction of the total number of base-station sites required, thereby reducing total network capitalization. In effect, HYPRES technology enables wideband 3G performance with GSM-type base station ranges. For an SDR configuration, significantly reduced longer-term network capitalization is also accrued due to much longer life cycles via the introduction of new and expanded services without hardware changes.

Significantly Reduced Operating Expenses – Fewer bases stations translates into fewer (costly) connected land lines and less power consumed. Less power consumed per base station is a further reduction. High reliability and nearly maintenance free operation significantly reduces operating cost. Resistance to surges and lightning strike effects means far less repair cost.

Enhanced Revenues and Margins — Because of the higher receiver sensitivity, resolution, and processing speed enabled by the HYPRES technology, more traffic for a given bandwidth allocation is possible, improving spectrum utilization. Our superior interference rejection results in higher call quality, fewer dropped calls, and, in turn, increased customer usage.

Boost Spectral Efficiency — Current state-of-the-art wireless systems only provide about 0.5 to 0.8 bits/sec/Hz, in terms of their ability to exploit (i.e. generate revenue from) an allocated bandwidth. In contrast, the HYPRES technology approach can provide more than 8 bits/sec/Hz, an order of magnitude improvement, and an opportunity for significantly improving spectrum utilization.

Spectrum Management — An example of the breakthrough applications enabled by our new technology is to incorporate a near real-time pipelined FFT in the receiver to dynamically monitor a broad area of spectrum and support acquisition of desired signals. With this approach, also used in communication surveillance applications, receivers sample relevant

bands in real-time and feed the information to intelligent controllers. This is a more effective approach to spectrum management than relying on status collected from individual radios. This technique makes possible:

- Rapid identification and acquisition of desired signals (including hopping signals)
- Spotting interfering emitters to support null steering of adaptive antennas
- Identification of intermodulation and spurious emission from cosited emitters using coincident timing (enabling reduction of interference in real time)
- Relaxation of modem requirements (with attendant cost and performance benefits);
- Compensation for frequency drift (transmitter, satellite, Doppler, etc.) reducing receiver-tracking requirements
- Reducing the frequency stability requirement of the transmitters (again, with cost and performance benefits)

By providing real-time information on the ambient spectrum, a number of event-driven spectrum management techniques are enabled, opening the way to move from monitoring spectrum to controlling it.

Future-Proof Technology — Because the HYPRES technology enables universal interoperability among legacy, current, and even future wireless protocols, (regardless of air interface or frequency used), it enables SDR with an agile business model which can quickly adapt to meet changing market environments, enhancing revenues and margins, further reducing long-term capitalization, and rapidly accommodate new initiatives (such as spectrum sharing and secondary markets). The hardware will accommodate generations of software upgrades and changes.

Exploit developments in SDR Technology — HYPRES products offer commercial wireless operators many valuable benefits that translate into higher sales, higher margins, significantly reduced capitalization and operating cost, significantly enhanced capabilities, a higher quality of service, and the introduction of new services. And orders-of-magnitude improved cost and operational effectiveness for military and civil wireless networks.

These performance characteristics permit the location of the ADC to a position adjacent to the antenna for reception and the corresponding DAC adjacent to the PA for transmission. This enables the next generation of true Software Defined Radio (SDR) technology throughout the base station, and facilitates development of near real-time frequency agile performance.[1] HYPRES technology totally supports the objectives of the commission[2]

HYPRES technology is an advanced superconductor technology, where electrical current flows indefinitely and the fundamental performance is derived from quantum principles. Digital logic building blocks using this technology provide digital circuits with much higher performance than can be achieved with semiconductor circuits. The first (very basic design) ADC produced by HYPRES, using relatively crude 3-micron lithography technology, outperformed the best semiconductor ADCs in every aspect. We believe that it is the only technology, now and in the foreseeable future, that will make the "dream" of a true software defined radio into a reality.

[1] FCC 00-41, Policy Statement In the matter of Principles for Promoting the Efficient Use of Spectrum by Encouraging the Development of Secondary Markets, Adopted November 9, 2000 (hereafter 'PS'), Par. 35, 36.
[2] FCC 00-401, WT Docket No. 00-230, Notice of Proposed Rulemaking in the same matter, Adopted November 9, 2000 (hereafter 'NPRM'), Par. 3,4

The ability of HYPRES to complete the development of these products is highly dependent on our ability to continue to acquire the necessary financing, which, in turn, is derived from the need for the capabilities associated with our products. The need for these robust capabilities is directly derived from the perceived direction of the marketplace. HYPRES is pleased with the innovative and futuristic direction being pursued by the FCC, and wishes to thank the FCC for having the courage to do so.

Secondary Spectrum Market Economics

HYPRES suggests that there are three interacting aspects to the economic success of the Commission's move to facilitate secondary markets and improve spectrum utilization: Need, Availability, and Facilities. We will address each.

1.) Need. The prospective lessee of spectrum from an FCC licensee must have a business case that predicts generation of enough revenue to cover the costs of operation with adequate margin to compensate for risk. The greater the risk, the greater the margin required. Consistent rulemaking and administration by the Commission will be perceived as reducing that risk.[3]

Nevertheless, the question of appropriate business cases must be addressed. The possibility of short term spikes in demand provides one such opportunity.[4] Such events, however, are not likely to be sufficient to support a robust market. In the long term, the leased spectrum must be available for a sufficient length of time to permit the lessee to obtain infrastructure and generate revenues perceived as adequate.

2.) Availability. There must be a licensee with available spectrum and motivation and a business case to consider relinquishing its use for a sufficient period of time to be of interest to the potential lessee. A cellular operator, for example, is not likely to want to help a competitor set up in business in the area they are trying to build out, even if the Commission relaxes its service rules and other requirements.[5] So the lessor is likely to be a licensee with no long term need for the specific spectrum desired, as is the case with TV stations making their retrace time available for data transmission.[6]

One result of a secondary spectrum market might be emergence of independent base station operators as a new participant in the market[7]. They could provide facilities that would lease channel capacity to service providers on a MHz-hour basis as power utilities do. Such an approach might lower "tower pollution," and could facilitate providing service to rural areas.[8]

3.) Facilities. Equipment capable of providing coverage on the spectrum to be leased is prerequisite to the business case. Most equipment currently in service is designed and built to

[3] NPRM Par. 8, 11, 83, 84
[4] PS Par. 13
[5] NPRM Par. 23, 40, 49
[6] NPRM Par. 91
[7] NPRM Par. 23
[8] NPRM Par. 2,7

meet the requirements of a particular service. Thus a CDMA operator with legacy infrastructure could not lease out 1.5 MHz of bandwidth and support TDMA service on existing equipment.

Software Defined Radio (SDR) technology changes that picture. In the future the option of a "universal" base station will be available. With this equipment the base station owner can use exactly the same equipment for a variety of services, and has the ability to change the mix of those services by changing the active software in the equipment. The cost of making changes is dramatically reduced, as is the time required to make them. A number of possible changes in the market ensue, improving the business case, increasing spectrum utilization, enabling new applications, and reducing operating cost.

Spectrum utilization can be improved by decreasing the time constant associated with spectrum allocation. At one extreme is the time needed for rulemaking by the Commission. Less time consuming is the use of a Frequency Coordinator who interacts with all of the participants in a particular service, checking to see if a proposed service will interfere with existing uses. At the short end of the allocation spectrum is cellular telephone where, under carefully controlled conditions, many users are simultaneously accommodated on a statistical basis by dynamic reassignment of channels and time slots or codes in a designated segment of spectrum.

With infrastructure based on SDR technology, there is a potential for moving frequency coordination from a 60 to 90 day time constant to a much shorter interval. During slack periods during the day (or night) channels from one service could be dynamically reallocated to another for a period of a few hours. Such sharing would use the methodology for frequency coordination now in place, but would automate it, giving response in a matter of minutes. A power company, for example, could ask for hours of channel capacity to collect meter readings, with an idle channel assigned that had taxi service as its primary application. Emergence of this class of application is dependent on availability of technically agile equipment in the infrastructure, and the business case to justify development of such equipment.

HYPRES supports the proposals for secondary markets for spectrum. We suggest that the issues of need and availability are appropriate for the rulemaking proposed by this NPRM. The third dimension, that of technically agile equipment to facilitate service availability is best served by further development of Software Defined Radio, as addressed in the SDR NPRM.[9]

Responses to Specific Paragraphs

Par. 8. …regulatory impediments to and uncertainties about secondary market arrangements create barriers to entry…

Among the resulting deterrents is the reduced market size for equipment caused by marginal business cases and uncertainty. As a secondary effect, equipment manufacturers are then denied economies of scale realized in more a robust market, which in turn keeps costs higher and

[9] FCC 00-430, ET Docket No. 00-47, Notice of Proposed Rulemaking In the Matter of Authorization and use of Software Defined Radios, Adopted December 7, 2000 (Hereafter 'SDR NPRM')

inhibits the availability of funds for both cost reduction and new product development engineering.

Par. 13. …explore whether additional flexibility in our technical and service rules would further enhance the development of secondary markets.

For existing applications to prosper and for new applications to succeed service providers need ready access to connectivity, including spectrum. Secondary market licensing is one means of providing that spectrum. The current certification requirements are recognized as an impediment. The SDR NPRM proposes that every combination of hardware and software be independently tested prior to certification[10]. The combinatorial expansion associated with such a requirement in growing markets will inhibit development of secondary markets.

Innovative means to detect, report, and deter out of band energy radiation are available with new technologies. For example, an SDR based receiver can act as an intelligent spectrum analyzer. It can be advised when a given co-sited channel is transmitting and look for contemporaneous spurious emissions (even though they are not on the same bands or in the same service). The result can be used to lock out the transmission, or, in less serious cases, provide an audit trail for post analysis.

Par. 29. …the licensee would remain ultimately responsible to the Commission for compliance…

Par. 36. …the licensee retains ultimate responsibility to ensure that the spectrum lessee complies with all of the interference, frequency coordination, and other technical rules applicable to the licensed spectrum being leased.

Par. 40. …the spectrum lessee would be required to comply with all other technical rules applicable to the licensed spectrum.

A fundamental condition of secondary licensing should be that all participants in a lease hierarchy have responsibility for compliance with respect to any operating parameters over which they have influence. As an example, cell phone owners may be held responsible for inhibiting an audible ring from their phone in a public situation, but not for the frequency over which they are communicating.

As spectrum utilization increases the potential for interference increases. With available error detection and correction techniques low level of interference can be tolerated, and are statistically less important in link performance than other problems such as fading and multipath. But above a certain level they need to be addressed. So further condition of licensing should be that all participants use equipment that can provide warning of specified conditions outside operating limitations.

[10] SDR NPRM Par. 18. suggests that testing each combination of hardware and software is no more burdensome than present practices. But present practices are recognized as an impediment to secondary markets.

For less dynamic rules, such as tower height and hours of operation, software radios do not present any new problems or capabilities. Such matters should passed from the licensee to any lessees as a matter of contractual duties.

Par. 65. …how licensees and lessees would coordinate frequency use with neighboring licensees and lessees so as to avoid interference.

There are many examples of such coordination currently in service. Trunked radios and cellular roaming are examples. In the computer communications domain, Ethernet cable-based technology has demonstrated the viability of operation with collision sense multiple access (CSMA) where conflicting emitters sense the conflict and back off to retry. SDR technology will enable such applications. There is the further prospect for using the thousands of idle terminals to determine availability of an open frequency in some service.

In other services frequency coordinators are commonly used. These focal points receive information about an intent to transmit from a specific station, and ascertain that no interference will result. These concepts could be developed and expanded to provide coordination among technically agile with SDR technology who communicate with each other to provide automated coordination.

Par. 76. …we tentatively conclude that we should not apply the *Intermountain Microwave* factors in the context of spectrum leasing.

Par. 78. …At the same time, we recognize that the leasing arrangements we propose here must include basic safeguards to prevent an unauthorized transfer of control under Section 310(d).

We concur. Some of those safeguards can be provided by requirements imposed on the software used in SDRs. Others can be contractual obligations.

Par. 84. …over time many different types of technical requirements have been developed in various services. To the extent that any of these become outmoded, they may pose artificial and unnecessary barriers to spectrum leasing.

Technical requirements in various services have evolved under influence of contemporary equipment technology used to provide the services. With SDR based systems many new capabilities are introduced. For example, spectral characteristics of a transmission can be measured by a co-located receiver, fed back to the receiver, and software parameters adjusted to pre-distort the signal, providing the desired envelope. This very general and powerful capability may permit relaxation of requirements, such as band edge roll-off, that were necessary in the past. Such a move has potential for increasing effective bandwidth, and making better use of spectrum.

Conclusion

HYPRES is confident that its technology, as part of the emerging hardware and software performance improvements, will enable true software defined radios. Our products will assist in making not only secondary markets possible, but will permit implementation of a host of services, functions, and capabilities that are not even conceived or contemplated at the present time.

We appreciate the opportunity to comment on the secondary market NPRM, and hope to work with the Commission in the future to facilitate further development of these technologies.

Respectfully submitted,

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HYPRES, Inc.

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