

**Before the
Federal Communications Commission
Washington, DC 20054**

In the Matter of

Facilitating Opportunities for Flexible,)
Efficient and Reliable Spectrum Use) ET Docket No. 03-108
Employing Cognitive Radio Technologies)

Comments of Pulse~LINK, Inc.

1. General Remarks

Pulse~LINK thanks the FCC for this opportunity to provide remarks concerning Cognitive Radio Technologies. Pulse~LINK, INC. a Delaware Corporation, hereby submits these Comments with respect to the Notice of Proposed Rule Making (NPRM) issued in the above captioned proceeding. The focus of these comments will be on wireless technologies and their coexistence with each other within the Radio Frequency (RF) spectrum. Pulse~LINK supports the Commission’s goals of promoting the use of “cognitive” radio technologies. Pulse~LINK is a leader in the Ultra-Wideband (UWB) communications industry and is currently developing a software definable cognitive UWB radio.

2. Cognitive Radio Technologies

The world of communications is a dynamic and rapidly changing arena in which technology is constantly evolving. The advent of wireless communication services is just one example of that rapid and dynamic change. Historically there have been a number of difficulties encountered in the wireless communications field. The “Spark Gap” invented in the 1890’s by Marconi was capable of broadcasting around the globe. Unfortunately for Marconi, by the 1920’s the airwaves were beginning to get crowded and “Spark Gap” transmitters did not play well with the new frequency based transmitters. As more frequency based transmitters began broadcasting audio the older spark

gap transmitters were displaced. Eventually, the newly formed FCC prohibited the use Spark Gap transmitters due to the potential interference issues associated with them.

Spectrum is generally apportioned into licensed and unlicensed bands. The concept of exclusive license is driven by the potential for harmful interference. “Mutual exclusivity is important because it is the statutory trigger as to whether the Commission is required to auction the spectrum.”¹ Coexistence is therefore at the very core of Spectrum Management Policy.

The seeds of unlicensed spectrum usage have their root in the 1938 FCC decisions to authorize radio devices to transmit on a sufferance basis.² Since that time, the FCC has continued to expand the spectrum allocations for unlicensed devices, recently opening up an additional 255 MHz of spectrum bandwidth in the 5.470-5.725 GHz band.³ The spectrum was made available for use by unlicensed National Information Infrastructure (U-NII) devices, which include Radio Local Area Networks (RLANs), operating under Part 15 of the FCC’s rules. This move is an example of an attempt to foster the development of new technologies and new capabilities that will serve the public interest.

With the development of Cognitive Radio (CR) technologies exciting opportunities are developing for more efficient use of licensed and unlicensed spectrum. Pulse~LINK agrees with the Commission’s comments that a “cognitive radios could negotiate cooperatively with other spectrum users to enable more efficient sharing of spectrum.”⁴ In that regard a standard method for negotiation and access should be required. Additionally, Pulse~LINK believes the Commission’s concerns for a licensed user or emergency service’s ability to reclaim spectrum are essential for the success of CR technologies. To ensure these goals are met Pulse~LINK offers a Common Signaling Mode (CSM) for the Commission’s consideration. Not only should the CSM be applied

¹ My Vision of the Future of American Spectrum Policy, Remarks of FCC Commissioner Kathleen Q. Abernathy Before the Cato Institute’s Sixth Annual Technology & Society Conference Washington, D.C. – November 14, 2002

² Summary of OSP Working Paper 39, Unlicensed and Unshackled: A joint OSP and OET White Paper on Unlicensed Spectrum Devices and Their Regulatory Issues, Keith Carter, Ahmed Lahjouji, Neal McNeil, May 2003, http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-234738A1.pdf

³ Report And Order, In the Matter of: Revision of Parts 2 and 15 of the Commission’s Rules to Permit Unlicensed National Information Infrastructure (U-NII) devices in the 5 GHz band. ET Docket No. 03-122, Released November 18, 2003.

⁴ Notice of Proposed Rule Making, In the Matter of Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies, Paragraph 20.

to all CR technologies, all wireless communications technologies in both licensed and unlicensed bands would benefit from a CSM. In other proceedings the Commission has indicated a similar mechanism could be mandated for all unlicensed devices.⁵ Specifically the commission proposes “to require all unlicensed devices to broadcast identification information at regular intervals.”⁶ Pulse~LINK believes requiring a CSM for all unlicensed devices will be in the interest of the American Public and will further a number of the Commission’s spectrum management goals.

3. The Common Signaling Mode for All Wireless Communications Devices.

Albert Einstein once said, “We cannot solve our problems with the same thinking we used when we created them.”

A CSM can provide the mechanism for regulation of licensed and unlicensed device operation. “The success of the unlicensed approach depends in large part on the Commission's willingness and ability to clearly define the rules that govern the service. This is important if capital, and in turn, services, are to flow to the American people. The threat of the tragedy of the commons is real. And the Commission must recognize that risk and respond accordingly if it is to protect the vital contribution of unlicensed services.”⁷ For licensed and unlicensed devices to implement a CSM would allow for significant benefits to all and would be inline with the spirit of the mission of the FCC.

The Common Signaling Mode (CSM) is a means by which disparate wireless technologies and devices may communicate with each other over a wireless interface. Ideally, it is a robust, reliable, “Lowest Common Denominator” wireless mode understandable to all air interfaces. The CSM is a methodology for allowing scalability and guaranteed Quality Of Service (QOS) with multiple different Physical layers (PHY) that allow technologies to coexist in the same spectrum bands and the same physical coverage areas simultaneously. The CSM could function as a

⁵ In the Matter of Unlicensed Operation in the Band 3650-3700 MHz Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band Amendment of the Commission’s Rules With Regard to the 3650-3700 MHz Government Transfer Band. Paragraphs 60-64.

⁶ Id. Paragraph 60

⁷ My Vision of the Future of American Spectrum Policy, Remarks of FCC Commissioner Kathleen Q. Abernathy Before the Cato Institute’s Sixth Annual Technology & Society Conference Washington, D.C. – November 14, 2002

communications channel for cooperative management of allocated PHY resources across the time and frequency domains. In addition to its basic function of a low-bandwidth signaling channel, the CSM could offer a wide range of additional functional capabilities. It has the potential to provide a variety of benefits to a user.

- A Beacon Timing Channel.
- A Beacon Ranging Channel.
- A Low-Bandwidth communications link for low-bandwidth devices.
- A power conservation functionality for mobile devices.
- A dynamic node-to-node power transmit/receive power control.
- Network status/health/control information.
- A low-bandwidth Over-the-Air-Reprogramming link.
- A low-bandwidth Over-the-Air-Rekeying.
- CSM could be utilized for through-wall imaging systems.
- CSM could be used to support the FCC's Cognitive Radio Initiative.
- It could be used to support the FCC's Interference Temperature Initiative.
- It could be utilized for area security systems.
- The CSM could also enable a "Shut Down" Protocol.
- The CSM could serve as the PHY layer for IEEE 802.15.4a.
- The CSM could be used in a Mesh Network for routing updates.

A primary use of the CSM would be to provide a method for bandwidth coordination between different wireless technologies. For example a CSM could permit two devices, one a wireless device utilizing a spread spectrum approach to Ultra-Wideband (UWB) and the other using an Multi-Band Orthogonal Frequency Division Multiplexing (MB-OFDM) approach to Ultra-Wideband, to negotiate usage of the local spectrum based on a time sharing between the two devices. Alternatively the two devices may be a Bluetooth device and an 802.11 device attempting to operate within the same 2.4 GHz spectrum.

The CSM, if properly designed, has the potential to provide a number of capabilities and services.

a. CSM could provide Beacon Timing Channel

By functioning as an out-of- channel communications mode that all wireless systems are capable of using, the CSM could provide for time precision across wireless networks by functioning as a wireless beacon. The concept of beacon signals is not new, they have been used in several different applications. For example, IS-95 uses the concept a Pilot Channel⁸ in a manner similar to the concept of a beacon. In IS-95, the Pilot Channel is the beacon by which mobile units identify the base station. Part of the CSM packet structure could be designed to support the concepts of a timing beacon and the sharing of time information across wireless networks. By sharing time estimations between wireless devices, it becomes possible to generate highly precise time estimates across the network. Higher time accuracy across the network has the potential to provide for increased capacity, especially in Time Division Multiple Access (TDMA) networks by allowing higher time precision TDMA protocols to be utilized.

b. CSM could provide Beacon Ranging Channel

The CSM could permit an access point to function as a wireless positioning beacon. By allowing an access point to function as a beacon node, positioning applications would become more easily implemented. The concept of a beacon ranging channel is not a new one, it has been used in the Global Positioning System where each satellite acts as a beacon ranging channel. Two-way ranging creates possibilities for even more accurate ranging information. For example, multiple wireless beacon nodes transmitting continual position location information on their own location and estimates of ranges to other devices would enable a mobile device to rapidly determine its location. This would allow outdoor and indoor E-911 applications to become truly realizable.

⁸ "TIA/EIA/IS-95-A: Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System", Telecommunications Industry Association, February 27, 1996.

c. CSM could provide Low-Bandwidth communications link for low-bandwidth devices

The CSM could function as a low bandwidth communications channel. Low bandwidth messaging could utilize the CSM; thereby saving bandwidth for users that needed it. For example, a low bandwidth security sensor need not utilize a high-bandwidth communications link to report its status information, thereby saving that high-bandwidth capacity for applications that needed it. It should be possible to design the CSM packet structure to readily support applications requiring low-bandwidth communications.

d. CSM could provide power conservation functionality for mobile devices

By functioning as a low-bandwidth communications channel, the CSM could enable power conservation in mobile or battery-limited devices. For example, devices requiring a low-bandwidth channel would not need to continuously monitor a high-bandwidth channel to acquire or pass low-bandwidth information. By utilizing the CSM, a mobile device is able to improve its power conservation, thereby ensuring longer operation.

e. CSM could provide dynamic node-to-node power transmit/receive power control

The CSM could be used by wireless links to dynamically control the power transmitted by each end of the link to ensure only the minimum transmit power needed to maintain the link was utilized by each end. This would be advantageous in applications such as mesh networking to ensure that the local RF environment was kept at the minimum level needed to maintain all the links. Additionally, the benefits of transmit power control through a CSM include the potential for a wireless device to take advantage of changing regulatory transmit power limits.⁹

f. CSM could provide network status/health/control information

If properly designed, the CSM could provide additional network functionality. Network status, health and control information could be readily provided over the low-bandwidth, out-of-

⁹ November 12, 2003 the Commission adopted a Report and Order amending parts 2 and 15 of the Commissions rules regarding U-NII devices in the 5 GHz range. This Report and Order specifically required Transmit Power Control to be implemented in devices taking advantage of this frequency allocation.

channel signaling mode the CSM would provide. For example, routing updates on node availability in a wireless mesh network could utilize the CSM instead of occupying a high-bandwidth link.

g. CSM could provide a low-bandwidth Over-the-Air-Reprogramming link

Functioning as a low-bandwidth communications link, the CSM could enable on-the-fly software definable radios (SDR) in which the CSM link was used to pass new communications algorithms to the target receiver to enable new waveforms in near real-time. By being able to reprogram a radio over a low-bandwidth communications channel wireless devices could be altered to improve their transmission characteristics or to improve their capacity. As regulations change with respect to software definable radios and other cognitive radios, the CSM may be used to update software and firmware to conform to the new regulations. This Over-the-Air Reprogramming will allow devices to comply with a changing regulatory environment, thereby reducing the cost of redesign and replacement of wireless devices to designers, manufacturers, and consumers alike.

h. CSM could provide a low-bandwidth Over-the-Air-Rekeying

Functioning as a low-bandwidth communications link, the CSM could enable key distribution for secure networks thereby enabling over-the-air-rekeying of encryption devices. Security is a major concern in wireless architectures, as well as in communications in general. Encryption is one means of securing a communications link, be it wired or wireless. Secure encryption typically uses encryption keys that need to be changed on a dynamic basis. By creating a low-bandwidth communications channel, the CSM could enable the wireless rekeying of devices using encryption.

i. CSM could be utilized for through-wall imaging systems

CSM could be designed to enable through-wall and ground penetrating radar imaging systems by creating packets that had packet structures or synchronization headers that were fixed in nature and could be utilized as an imaging pulse train. For example, a packet training sequence could be designed to support through-wall imaging systems. Using the CSM, the through-wall

imaging system need not transmit its own, special pulse sequence, thereby impacting the local radio frequency environment. Instead, perhaps the imaging device could utilize the CSM transmissions from other, near-by devices to complete its through-wall imaging.

j. CSM could be used to support the FCC's Cognitive Radio Initiative

A paper presented to the IEEE has defined the Cognitive Radio as “a radio frequency transmitter/receiver that is designed to intelligently detect whether a particular segment of the radio spectrum is currently in use, and to jump into (and out of, as necessary) the temporarily unused spectrum very rapidly, without interfering with the transmissions of other authorized users.”¹⁰ The FCC has defined Cognitive Radio technologies as those that “make possible more intensive and efficient spectrum use by licensees within their own networks, and by spectrum users sharing spectrum access on a negotiated or an opportunistic basis. These technologies include, among other things, the ability of devices to determine their location, sense spectrum use by neighboring devices, change frequency, adjust output power, and even alter transmission parameters and characteristics.”¹¹ The FCC believes that cognitive radio technologies have the “potential to overcome some of the incompatibilities that exist between various communication services both domestically and worldwide.”¹² The CSM could provide a cognitive radio the means by which spectrum negotiations could take place between transmitters.

k. CSM could be used to support the FCC's Interference Temperature Initiative

Another FCC initiative is the concept of Interference Temperature. The FCC's ET Docket No. 03-237 is a request for comments on the concept of a new model for quantifying and managing interference, called Interference Temperature. The FCC hopes 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 RF environment seen by a receiver while simultaneously taking into

¹⁰ “Improving Spectrum Usage Through Cognitive Radio Technology”, IEEE Position Paper, 13 Nov. 2003, <http://www.ieeeusa.org/forum/POSITIONS/cognitiveradio.html>.

¹¹ “ET Docket No. 03-108, Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies”, Federal Communications Commission, December 17, 2003.

¹² Id.

account the interactions between transmitters and receivers. The interference temperature model represents a fundamental paradigm shift in the FCC'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, from both transmitters and potential noise sources, that is present at a receiver at any instant of time. Utilizing this new measure, the interference temperature limit for the band would serve as an upper bound on the potential RF energy that could be introduced into the band. By changing the current paradigm, the FCC hopes to increase the efficient use of spectrum and ensure coexistence of different wireless systems and technologies. A CSM would support the FCC's concept by creating a signaling channel that could be used by transceivers to communicate information on the local interference temperature. This would allow transceivers to dynamically adjust transmit power based upon the target receiver, thereby ensuring the local interference temperature limit are not exceeded.

l. CSM could be utilized for area security systems

CSM could be designed to enable area security systems, which would utilize the CSM as a radar-like detection signal. By appropriately designing the CSM, it may be possible to develop a packet sequence that could be used to detect motion within the area of the local device. It may be possible for a device to utilize the CSM transmissions from other devices as a detection signal. Such a capability would allow a wireless device to become its own security sensor.

m. The CSM could also enable a "Shut Down" Protocol

Wireless devices are not readily accepted in all locations for reasons that vary from security concerns to social reasons. For example, wireless devices are not yet approved for use on airplanes for safety of flight reasons; they are not approved in hospitals for safety of life reasons; and they are typically not desired in movie theaters for social reasons. The CSM could be designed to turn off CSM enabled wireless devices when a CSM device entered such an area.

n. The CSM could serve as the PHY layer for IEEE 802.15.4a

The CSM could function as the IEEE 802.15.4a, Alternate Physical Layer Extension for Low Rate Wireless Personal Area Networks (WPAN), by providing communications and high precision ranging and location capability (with the goal being 1-meter accuracy or better), higher aggregate throughput, and significantly lower power. The 802.15.4a working group has been tasked with defining just such a standard and the concept of a CSM fits right into the existing definition.

o. The CSM could be used in a Mesh Network for routing updates

One problem in mobile mesh networks is the updating of routing information to nodes that are already saturated with traffic. By functioning as a separate, out-of-band signaling channel, the CSM could provide updated routing information to saturated nodes, thereby permitting them to off-load traffic to different nodes. Additionally, traffic bandwidth would not be used up by common routing information, which would be sent by the CSM instead of occupying a traffic channel.

4. An FCC Requirement for a Common Signaling Mode in All Wireless Communications Devices Furthers a Number of Spectrum Policy Management Goals.

Besides the supporting the Interference Temperature and Cognitive Radio initiatives as discussed above, a CSM furthers a number of other FCC objectives. By requiring a CSM for wireless communications devices, the FCC would be encouraging the highest and best use of spectrum domestically and internationally. This encourages the growth and rapid deployment of innovative and efficient communications technologies and services, as required by 47 CFR 301 and 303(g). As discussed below, the CSM furthers all general objectives for spectrum defined in the FCC Strategic Plan FY 2003-2008.

a. Advance Spectrum Reform by Developing and Implementing Market-Oriented Allocation and Assignment Reform Policies.

Flexibility of use promotes a market-oriented allocation system. “In a market allocation of spectrum, markets, not central authorities, determine spectrum uses and users. An ideal market

allocation should impose no restrictions on spectrum uses and users beyond those necessary to limit interference, to prevent anti-competitive concentration, and to comply with international agreements. Spectrum should not be set aside for federal users or for specific non-federal users such as public safety providers, and public users should be allowed both to sell spectrum and buy spectrum from the private sector. For example, police and fire departments should be able to sell some of their spectrum and use the proceeds to buy new spectrum-conserving radios that could provide greater capacity and interoperability.”¹³

An environment wherein a communications device may negotiate a license with a network to use spectrum would require a standard protocol for negotiation of a license. This standard protocol should be common to all wireless devices. A CSM is the logical solution to further this objective.

b. Vigorously Protect Against Harmful Interference and Enforce Public Safety-Related Rules.

As described above a CSM enabled device may communicate important parameters to other devices. For example, a fixed access point may communicate to each mobile device the location of fixed transceivers and their known transmit powers and potentially their receiver sensitivity. A mobile device within the geographical coverage area of the known fixed transceiver may adjust its power level to prevent interference to the fixed service. Additionally, once a device calculates a local interference temperature it may communicate this information to other devices across a CSM as described above. When operating under a negotiated license within a public safety related frequency band, a CSM would allow the network to send a shutdown command to the device if the network needs to reclaim the spectrum for emergency use.

c. Conduct Effective and Timely Licensing Activities that Encourage Efficient Use of the Spectrum.

Automated licensing in the secondary market will require a standard interaction between a network and a device wishing access to the spectrum. A CSM can provide the protocols for this automated interaction.

¹³ “A Proposal for a Rapid Transition to Market Allocation of Spectrum”, Evan Kewel, John Williams, November 2002, http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-228552A1.pdf

d. Provide Adequate Spectrum and Improve Interoperability for Better Public Safety and Commercial Purposes.

The CSM improves interoperability between all wireless communications devices. Additionally, it provides for automated bandwidth allocation between services. With the addition of interference temperature calculation by the devices and a CSM, public safety and commercial pursuits are better served because the potential for harmful interference to public safety wireless services is mitigated.

5. Design Goals for a Wireless CSM

A CSM for all wireless communications devices has the potential to offer a wide range of capabilities to the users and to simplify the modernization of spectrum management. A CSM should incorporate as many of the capabilities as is possible given the current technology. It is essential that it should provide for scalability to include other services and capabilities as the progression of technologies permits. At a minimum the design goals for a **“CSM should include”**

- A timing beacon.
- Information on coarse SYNCH, diversity, frequency acquisition, AGC, channel estimation, and protocol selection.
- A mechanism for a low power sleep mode.
- It should enable geo-positioning.
- It should provide for transmit power control.
- It should function as a low data rate link when channel conditions won't permit a high data rate link.
- It should address coexistence and interoperability among wireless devices.
- It should be low cost to implement.
- The CSM could be implemented as either a mandated RF channel across all wireless communications devices or as an abstraction layer protocol within each technology.

6. Increased Transmission Limits for Cognitive Radios

Pulse~LINK supports the Commission's intention to allow CR technology enabled devices to transmit at increased power levels in areas of spectral limited use. The Commission proposes to define "unused spectrum" as spectrum with a measured aggregate noise plus interference power no greater than 30 dB above the calculated thermal noise floor in a 1.25 MHz measurement bandwidth.¹⁴ The proposed authorized bands for increased power limits include the 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz, and 24.0-24.25 GHz bands.¹⁵ The same or similar requirements should be applied to indoor UWB systems operating under 47 CFR 15.517 and handheld UWB systems operating under 47 CFR 15.521. Applying the increased power limitations to UWB devices should be allowed only when the UWB device employs the ability to "listen-before-talk" and has transmit power control mechanisms as discussed in this and other proceedings.¹⁶

7. Conclusion

The world of wireless communication only continues to grow and expand, with new technologies continually being developed. The usage of spectrum will only continue to grow as wireless technologies continue to be developed. The Common Signaling Mode (CSM) is a potential method by which disparate wireless technologies could communicate with one another to negotiate the use of spectrum on an interference free basis. The CSM could be a critical factor in enabling technologies such as cognitive radios and viral communications systems by functioning as a signaling protocol between different wireless communications technologies and systems. By functioning as a "least common denominator" communications link between all wireless systems, the CSM could bring about the full capabilities of technologies such as cognitive radio and viral

¹⁴ NPRM paragraph 44.

¹⁵ Id. See also 47 CFR 15.247 and 15.249.

¹⁶ Report and Order, In the Matter of Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (UNII) devices in the 5 GHz band., Released November 18, 2003.

communications systems and allow a harmonious use of spectrum between different and competing wireless technologies.

The FCC should require Advanced Telecommunications wireless devices to implement a CSM. By adopting this requirement the FCC can meet its goals stated in the Strategic Plan FY 2003-FY 2008. Additionally, by requiring a CSM in wireless communications devices, the exciting new devices currently under development can be brought to market without concerns of coexistence and harmful interference. Additionally, secondary markets for spectrum can be implemented in a standardized manner allowing more efficient use of this precious national resource.

Respectfully Submitted
Pulse~LINK, Inc.

By: submitted electronically
John Santhoff
CTO/CEO

Steve Moore JD., Ph.D.
Director of Intellectual Property

1969 Kellogg Avenue
Carlsbad, CA. 92008
760 607-0844