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Federal Communications Commission
Office of Secretary

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W., Room 222
Washington, D.C. 20544

Re: GN Docket Number 96-228 Out-of-Band Emission Limits for the Wireless Communications Service ("WCS")

Dear Mr. Caton:

Pursuant to Section 1.1206 of the Commission's Rules, enclosed please find an original and two copies of the *ex parte* technical statement of Bellcore on behalf of the PACS Providers Forum in the above cited proceeding for inclusion in the public record. This submission is intended to address issues raised by the Commission's Staff regarding technical aspects of the out-of-band emission limits on operations in the WCS bands.

In its technical statement, Bellcore reaffirms and explains why a service operating in the A or B bands of the WCS spectrum will cause no greater interference to the proposed operations of the DARS applicants than the generally applicable out-of-band emission limitations currently provided by the Commission's rules, if technical operations conform to the following criteria:

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- a 12.5% duty cycle for all portable units, with a 312.5 μsec pulse every 2.5 msec
- the portable units must employ TDMA technology
- Subscriber Unit ("SU") transmit power of 200 milliwatts peak (25 milliwatts average output)
- Radio Port ("RP") transmit power of 800 milliwatts for RP at 25' height (for base stations mounted higher, the power may be raised in accordance with the additional path loss afforded by the greater distance)
- linear polarization
- only fixed (wireless local loop) and portable services may be provided (*i.e.,* no vehicle-mounted units are permitted).

then the following out-of-band emission standards:

- subscriber unit transmit emission levels of 81 + 10 log (P) dB
- base station transmit emission levels of 75 + 10 log (P) dB.

Specifically, the combination of (i) a low probability of multiple PACS handsets being in close proximity to a DARS receiver, (ii) the universal use by the DARS applicants of interleaving and error correction technology and (iii) compliance with the out-of-band emission limits noted above result in PACS-type systems having a minimal and acceptable impact on the performance of DARS.

Should you have any questions, please do not hesitate to call me at (202) 637-2172.

Very truly yours,

John Holland

John G. Holland
of LATHAM & WATKINS

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March 27, 1997

Bellcore

Bell Communications Research

PACS in the WCS Band: A Summary of The Issues

Introduction

The purpose of setting out-of-band emission limits for Wireless Communication Service (WCS) transmitters operating between 2305 - 2320 and 2345 - 2360 MHz is to limit, to a tolerable level, the interference from these transmitters on the satellite Digital Audio Radio Service (DARS) operating in nearby bands. Deciding what is a "tolerable" level of interference is critical in determining out-of-band emission standards because it is not possible to completely eliminate the interference that one radio system causes another. Therefore, the objective of setting out-of-band emission standards from the WCS band should concentrate on what level of interference to the DARS is tolerable.

What is a tolerable level of interference? DARS operators will already have to tolerate higher levels of impairments when the path between the satellite and the DARS receiver is blocked. This could occur when the vehicle carrying the DARS receiver passes under an overpass, travels on roads with heavy tree canopies, travels in an urban canyon, etc. Background noise will also cause interference. The noise level in an urban environment is typically higher than the noise level in a rural environment. Satellite designers accept these higher levels of interference and deal with them in a statistical way. Under the worst set of circumstances the DARS service will suffer an outage. Because of this, DARS service providers cannot guarantee service 100% of the time, but instead select a tolerable level of service.

There is an extremely low probability that multiple PACS handsets and a DARS receiver will be in close proximity to one another. In addition, DARS interleaver and Forward Error Correction (FEC) technology can deal with interference from one or two PACS handsets regardless of the distance between the DARS receiver and the handset(s). The combination of (1) a low probability of multiple PACS handsets being in close proximity to a DARS receiver, (2) DARS interleaving and FEC technology and (3) PACS compliance with the out-of-band emissions limits of 81 + 10 Log (P) dB for the handset and 75 + 10 Log (P) for the fixed unit, results in the PACS system having a minimal impact on the performance of the DARS system.

Analysis

To deal with interference caused by traveling under an overpass or tree canopy DARS will need to employ interleavers and FEC codes. These same technologies will also mitigate the impact that PACS has on DARS. A PACS handset in close proximity to a DARS receiver only transmits for 312.5 microseconds every 2.5 milliseconds. The DARS interleaver and FEC technology will be designed to handle fades on the order of seconds. This same technology will easily deal with interference from nearby PACS mobile terminals. How does the interleaver and FEC reduce the impact of PACS? Error encoding is just the calculated use of redundancy. More bits than are actually needed to transmit the digital music are sent over the air. These extra bits are used at the other end to correct any errors that occurred in transmitting the signal. Extra bits are added to groups of digital music bits called frames and the error coding is capable of correcting a small number of bits in error within the frame. A bursty error like the ones caused by traveling under an overpass may result in a whole frame being lost. In this case error correction codes cannot recover the frame. To avoid this situation a process called interleaving is used. Bits of different frames are interleaved with one another prior to transmission. If a bursty error occurs while transmitting the signal over the air only a couple of bit from each frame will be lost instead of the whole frame. A nearby PACS terminal will cause errors in only a few bits of a frame and therefore the error correcting codes will be able to deal with PACS interference.

PACS will interfere with DARS and no one on either side of the argument disputes this fact. The real question is how much interference from PACS can DARS tolerate and still provide a high quality service? Let us first consider a PACS handset nearby a DARS receiver. We all know that signal strength decreases exponentially with distance. Therefore at some distance the PACS handset will no longer cause an unacceptable level of interference. Figure 2 shows a PACS cell with PACS handsets labeled with a "P" and a DARS mobile labeled with a "D". The radius of a PACS cell is approximately 1,500 feet. The PACS Providers Forum (PPF) and DigiVox Corporation believe that the level of interference from a PACS handset to a DARS receiver will be acceptable when they are separated by more than 12 feet. Performance of the DARS receiver inside a 12 foot radius from the PACS handset may suffer from PACS interference. **The key question then becomes what is the probability that the DARS receiver will be within 12 feet of the PACS handset?** PACS has a reuse factor of 16. Therefore, in 5MHz of

bandwidth, there will be one frequency channel available for use in each cell. One frequency channel can support at most 7 PACS users. Let us suppose that both the A and B block of the WCS band are used for PACS. Then, at most 14 PACS handsets will be in use in a cell at one time. Statistically from traffic considerations, 8 handsets will be in use in a cell at one time, however, we will assume 14 users per cell. The probability of a DARS receiver being within 12 feet of a PACS handset is:

$$P = 14 \cdot \frac{12^2}{1500^2} = 0.000896.$$

This is less than a $1/10^{th}$ of a percent. The PPF number of 12 foot includes shadowing due to the human head and other factors that the staff of the Federal Communications Commission (FCC) expressed concerns over. Let us double the radius to 24 feet to reduce their concerns. The probability of being within 24 feet of a PACS handset is:

$$P = 14 \cdot \frac{24^2}{1500^2} = 0.003584.$$

This is less than $4/10^{th}$ of a percent and does not include head shadowing. Any shadowing caused by the human head or other objects will reduce the area in which the PACS handset may adversely impact the DARS receiver and hence will proportionally lower the probability discussed above. For example, if the human head shadows 50% of the signal, then the probability above would be reduced by a factor of 2.

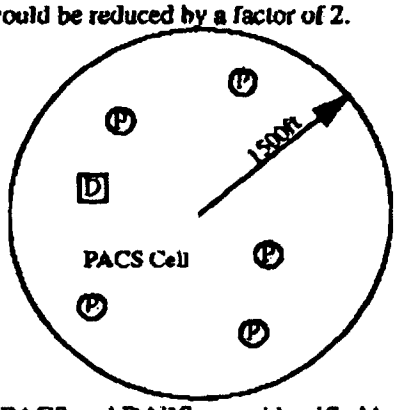

Figure 2. PACS Cell with PACS and DARS users identified by "P" and "D" Respectively.

In addition, the above set of calculations are overly conservative because they do not consider PACS power control. PACS handsets are power controlled and their power can be reduced by up to 30dB. This implies that handsets near the center of the cell will transmit at lower powers and cause less interference. Therefore, the radius at which the PACS interference is tolerable will be less for handset operating near the center of the cell, and the probabilities discussed above would be reduced. For example, a 6dB decrease in the transmit power of half of the PACS handset in a cell would result in a 35% reduction in the probability of a PACS handset interfering with a DARS Receiver.

These probabilities do not address the ability of the DARS interleaver and FEC codes to completely mitigate the interference from one or two nearby PACS handsets. **In reality, only multiple PACS handsets in close proximity to a DARS receiver will adversely impact the DARS receiver.** The probability of multiple PACS handsets being in close proximity to a DARS receiver is much lower than predicted above.

Conclusion

There is very little chance of being near enough to a PACS handset that it will cause an unacceptable level of interference to a DARS receiver. The probability of a PACS handset interfering with a DARS receiver is probably far less than passing under an overpass or tree canopy. Even when a DARS receiver is in close proximity the same interleaver and forward error correcting technologies that deal with fades due to traveling under an overpass or tree canopy will deal with the interference from PACS.

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Hamilton (Pete) Arnold received his Doctor of Engineering Science degree in Electrical Engineering from Columbia University in 1971. He joined the Radio Research Laboratory at Bell Laboratories, where he studied mobile and portable radio communications techniques and propagation, earth-satellite propagation, and advanced communications satellite system architectures. He joined the Radio Research Division at Bellcore at divestiture in 1984, where he currently manages a department conducting research on radio propagation, radio techniques, and systems analysis for portable and satellite communications. Dr. Arnold is a member of Sigma Xi and URSI Commission F. He received the Marconi SpA Prize and was elected an IEEE Fellow for his experimental research on earth-satellite propagation.

Howard Sherry is a Chief Scientist and Director in the Wireless Research Department at Bellcore where he is responsible for architecture, mobility management, economic assessment, and protocol definition efforts associated with wide area wireless access networks. Howard has both lead and participated in a number radio related professional services consulting engagements for major PCS / cellular service providers. In addition, he has been active in PCS standardization efforts in the United States since their inception. Howard served on the executive committee that organized and conducted the Joint Experts Meeting on PCS Air Interface Standards and has chaired several of the ad hoc committees in the Joint Technical Committee on Wireless Access standards. Prior to assuming his current position, Howard managed efforts involved with planning and laboratory implementation of high speed data networks, high-definition television services, and broadband multimedia services. Previously, he has had responsibility for managing advanced network architecture planning and Signaling System No. 7 standardization efforts. Howard has a Ph.D. and M.S. in electrical engineering from the University of Pennsylvania and a B.S. in electrical engineering from Worcester Polytechnic Institute.

Bob White is the Director of Wireless Loop Technology at Bellcore. He and his team are responsible for planning, engineering and implementing wireless local loop systems both domestically and internationally. His group performs initial business analysis of alternative systems, investigates the areas to be covered, develops detailed network and operations plans, provides engineering solutions for backhaul and interconnection, and supports the system deployment and testing. Bob is president of the PACS Providers Forum, which is an industry group dedicated to advancing the PACS technology. The PACS Forum does this through industry education programs such as seminars, promotion campaigns, support for standards evolution, and regulatory activity. Its members include PACS system manufacturers and supporting technology vendors, system software developers, system integrators, and wireless operators. Previously, Bob led a software development group building new network capabilities and operations systems to provide integrated wireless voice and data services. He worked on the national CCS/SS7 implementation team where he lead the CCS interconnection service development effort. Bob has also had involvement in developing and evaluating CLASS, Multiswitch Business Group, Private Virtual Network and PCS Access Services. Bob joined Bell Labs in 1980 and Bellcore in 1984. He has a Masters Degree in Mathematics from Arizona State University and a Ph.D. in Applied Mathematics from Michigan State University. Bob has published many papers in professional technical journals as well as papers treating telecommunications business and regulatory issues.

Paul Zablocky joined Bellcore after working with Science Applications International Corporation (SAIC) and the Center for Naval Analysis (CNA), the Navy operations think tank. At SAIC, Dr. Zablocky was a radar systems engineer in the Technology Research Group where, among other things, he designed, modeled and analyzed antennas and their interactions with surrounding structures. Paul also served as a program manager for a low altitude missile exhaust plume measurement program. While at CNA, Paul analyzed the performance of multiple military data links and their interfaces. With Bellcore since 1995, Dr. Zablocky is a recognized expert on personal communications systems (PCS). His knowledge of CDMA and IS-41 has earned him recognition from several major telecommunication service providers and CDMA manufacturers. Currently, Dr. Zablocky is modeling electromagnetic propagation at PCS frequencies. Paul earned his Ph.D. in Electrical Engineering from the University of Pennsylvania in 1992, his MSEE in Electrical Engineering from the University of Central Florida, and his BS in Physics and BSEE from Fairleigh Dickinson University. Dr. Zablocky is a member of IEEE and Eta Kappa Nu, and participates in standards meetings of the T1S1 Mobility Management Application Protocol (MMAP).