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Ad Hoc Alliance for Public Access to 911

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September 10, 1998

Magalie Salas
Secretary
Federal Communications Commission
1919 M Street, NW, Room 814
Washington, DC 20554

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Re: Ex Parte Information
CC Docket 94-102

Dear Ms. Salas:

On September 9, 1998 the enclosed report was provided to Mr. John Cimko. The report was developed by Trott Communications Group. It provides additional detail regarding the Ad Hoc Alliance's proposal to connect wireless calls to 9-1-1 services with the strongest compatible signal.

Sincerely,

Jim Conran

Jim Conran

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TROTT
COMMUNICATIONS GROUP

August 19, 1998

The Ad Hoc Alliance for Public Access to 911 (Alliance) asked Trott Communications Group, Inc. (Trott) to:

1. Assign a numerical value to the signal level at the edge of the portable grade coverage area (i.e. minimum signal strength for communication using a portable cellular telephone,

2. Assign a numerical value to the signal strength level that will predictably (based on Trott's experience and expertise) result in a "good" channel of communication using a portable cellular telephone, and

3. Render an opinion on the cost and time required for cellular telephone manufacturers to design and install a threshold signal strength "gate" in the handset before selecting the strongest compatible signal.

Trott, like all other engineering firms, maintains an extensive library of reference material to assist in resolving technical and other design issues. Included in this report are excerpts from two of those publications which were written by Dr. William C. Y. Lee, "Mobile Communications Engineering - Theory and Application" 2nd edition (MCE) and "Mobile Cellular Telecommunications - Analog and Digital Systems" 2nd edition (MCT). We chose these volumes as they contain frank and open discussion of coverage performance, limitations and the gap issue and its causes from a recognized expert within the cellular industry.

Perhaps a brief tutorial on the philosophy of cellular system coverage design will aid in clarifying this issue. Coverage in a cellular system is affected by the terrain throughout the service area, the transmitter power and the height of the antennas. As Dr. Lee points out in Chapter 1 of MCT (pg. 10) concerning Service Quality,

> *"... it is usually not practical to cover 100% of an area ... the transmitted power would have to be very high to illuminate weak spots ... the higher the transmitter power, the harder it becomes to control interference. Therefore, systems usually try to cover 90% of an area in flat terrain and 75% of an area in hilly terrain".*

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In their initial implementation, cellular systems were designed to optimize "coverage" with cell sites spaced relatively far apart. This led to a noise-limited system wherein the presence of interference from the next cell site reusing the same frequencies was minimal or nonexistent. As system demands increased, the need for more capacity in a given area led to the "splitting" of these "coverage" cells into "capacity" cells so that frequency reuse can be utilized to increase overall system capacity.

Cell splitting can continue to occur as traffic demands increase and this has happened in the core of each cellular market today. Cellular systems depend on the reuse of frequencies in fairly close proximity to gain the traffic handling capacity necessary. The increase in the number of cell sites and their reduction in size has changed the cellular radio environment in the urban and close in suburban areas into an "interference-limited" system. Radio waves do not stop propagating at the edge of a cell site, they continue to move outward from the cell site until they are attenuated by obstacles, free space and terrain to the point that they are no longer detectable. This distance of influence is the challenge faced by the radio engineer in designing a usable cellular system.

The growth in the number of cells in the core and close-in cellular markets has resulted in "portable grade" coverage in those portions of many cellular networks. This means that the portable handset user is not disadvantaged in being able to access and use those portions of the cellular network as compared to the mobile cellular user attempting access from the same location. Both the portable handset and the mobile are power controlled by the cell site and they effectively look alike to the cellular system when they are operated in close proximity to a cell site.

Issue 1: Signal Level requirements for Portable Grade Coverage

As stated by Dr. Lee on (MCT pg. 59):

> *"Reusing an identical frequency channel in different cells is limited by cochannel interference between cells, and the cochannel interference can become a major problem. ... The cell size is determined by the coverage area of the signal strength in each cell. As long as cell size is fixed, cochannel interference is independent of the transmitted power of each cell. It means that the received threshold level at the mobile unit is adjusted to the size of the cell."*

Hence, as the cell size decreases, and as a direct result the spacing between co-channel cells decreases, the resultant co-channel interference signal level increases. The cell boundary, therefore, is the signal level at which handoff is requested (due to inadequate signal level) or required (due to co-channel interference). The handoff level is set for the

cell, based upon the size of the cell, to insure that handoff occurs before the call is dropped. The ratio of the strength of the desired carrier signal to the strength of the undesired (interfering) carrier signal is represented as C/I or Carrier to Interference Ratio. In our experience, and as found in
(MCT pg. 283),

> *" the value of C/I at the cell boundary for handoff should be 18 dB in order to have toll quality voice."*

If a handoff is necessary due to signal level rather than C/I, as further stated by Dr. Lee in (MCT pg. 283):

> *"the signal strength threshold level for handoff is -100dBm for noise-limited systems and -95dBm for interference-limited systems."*

Handoff due to weak signal level is necessary according to Dr. Lee (MCT pg. 283):

> *"... at the cell boundary ... and ... when the mobile unit is reaching the signal level holes (gaps) within the cell site..."*

Since the question posed by the Alliance concerned Portable Cellular Phones, we must account for the efficiency of the portable's antenna. The differential between a gain antenna mounted on an automobile and a short (1/4 wavelength or less) antenna without a groundplane, that is usually not positioned exactly vertical could be -6dB or greater loss.

Therefore, to answer the question posed by the ALLIANCE, the signal level at a cell boundary is -94dBm for noise-limited systems, -89dBm for interference-limited systems, or 18dB C/I.

Issue 2: Signal Level requirements for "Good" Channel of Communications using a Portable Cellular Phone

Our experience has shown that portable handset and mobile unit system access parity **is not present** in the outer suburban and rural cellular coverage areas. The rural and outer suburban disparity stems from the limited transmitter power available from the portable compared to the higher power mobile and in part from the different types of antennas used on portable handsets versus mobile units. More and more, portable handsets are replacing mobile units and users are treating these portable handsets as if they were mobile units by placing and receiving calls while driving. This usage practice exacerbates the coverage issues faced by the portable user by introducing additional losses in the signal path by the shell of the automobile and its tinted window glass (4 to 6 dB).

Portable handsets also can and are used inside of buildings which introduces additional obstacles (and losses) in sending and receiving adequate signal for communications as shown by Dr. Lee in (MCT pg. 419):

> *"signal strength requirements at the first floor inside the building for the portable unit to be -12 dB" (intermediate value).*

When a cellular phone is in motion, it experiences a fast signal fading known as the "Rayleigh Fading" effect. This phenomenon results in the mobile unit coverage being based upon, as stated by Dr. Lee in (MCE pg. 582):

> *"the strength of a carrier signal averaged over time (or over a distance)".*

When a cellular phone is used from a fixed location or one where motion is slow, the effect of Rayleigh fading becomes minimal while the effect of Frequency Selective fading becomes dominant. Therefore, when a cellular phone is used in this stationary mode, the coverage is, as stated by Dr. Lee in (MCE pg. 582):

> *"... based on the signal strength at one spot, not the average signal strength."*

A cellular call involves four frequencies to complete; Forward Control Channel; Reverse Control Channel; Forward Voice Channel; and Reverse Voice Channel; therefore, as Dr. Lee states(MCE pg. 583):

> *"The definition of portable coverage is based on all four frequencies being above a given threshold level".*

In the core and close-in cells, the available signal strength is high due to the proximity of the cell site to the user (small cell size) and the threshold of usable signal is easily exceeded by the available signal, if the unit is not being operated indoors where additional signal attenuation is being experienced. In the rural and outer suburban areas, due to the reduction in available signal caused by the larger cell size, the portable handset coverage area where all four frequencies are above a usable threshold is reduced to 65.6% of the total area of the cell site according to Dr. Lee (MCE pg. 583). Therefore, as a general proposition, calls from a portable cellular telephone will not be successfully completed approximately one third of the time in these rural and outer suburban cells. We do not expect to see any dramatic change in this situation in the foreseeable future.

The net result of all of these effects paints a somewhat grim picture for the portable handset user's coverage area. In the core and close-in suburbs, the portable handset user will find fairly good signal available on the street. Usage of the handset inside moving vehicles and inside buildings on the lower floors is problematic if cell size becomes too large to provide sufficient signal at the portable handset to overcome the additional losses encountered (-8 dB due to Rayleigh fading; -4 to -6 dB inside a vehicle and -12 dB inside buildings at the first floor). Common practice today has resulted in core cell interference signal levels that force handoff to occur at approximately -85dBm to maintain the 18 dB C/I requirement at the cell boundary.

Therefore, to answer the second question posed by the ALLIANCE, the signal level requirements for "Good" Channel of Communications using a Portable Cellular Phone at a cell boundary is -85dBm for noise-limited systems and -80dBm for interference-limited systems. This level is derrived from:

-89dBm	(Interference-limited threshold)
+9dB	(average of vehicle, building and Rayleigh Fading loss)
-80dBm	Portable Gate Threshold

Based on our experience, it is our opinion that a "good" channel of communication between a portable cellular telephone and the cellular system must provide an 18 dB C/I ratio. Selecting a signal strength threshold that represents this quality leads us to a "handoff" or "Gate" threshold of -80dBm. Prudence dictates that although this level is slightly higher than common practice today, it is necessary to support portables experiencing a 4-signal composite reliability between 65.6% and 90%. Signal levels weaker than this "gate" threshold increase the likelihood of degrading the C/I ratio to less than the 18 dB needed to maintain "good" communications. Likewise, signal levels weaker than this "gate" threshold decrease the likelihood of maintaining "good" communications in a stationary environment, especially in a rural, hilly cell coverage area.

Issue 3: The Alliance requested that Trott analyze and provide an assessment of the costs which manufacturers of cellular phones would incur and the time that would be required in order for the manufacturers to design and install a threshold signal strength "gate" to enable cellular telephones to employ a "strongest signal" selection process with respect to calls made to 9-1-1.

Based on our analysis, we feel that minimal effort would be required to implement such a threshold "gate" to enable strongest compatible signal selection when the phone experiences a signal level below threshold upon dialing 9-1-1. This "gate" design and installation will have minimal, if any, impact on hardware or software, since cellular telephones as currently manufactured already measure RSSI signal levels in order for the phones to function properly according to the current cellular standards. The manufacturer may need to calibrate this measurement process and then store a correction factor or a corrected "gate" value in the handset memory. Most of the manufacturer's already test and calibrate the RSSI measurement task in their handset software today to enable display of the signal strength being received. Enhancing this task should not exceed several weeks of program development. Once the software is developed, there is no additional costs involved in loading it into each handset during manufacture. This should be a very low cost effort.

This report was prepared by:

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