ORIGINAL

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

ORIGINAL FILE

In the Matter of	)	
	)	
Paging Network Inc.	)	ET Docket No. 92-100
	)	
Request for a Pioneer's Preference For Pioneering the Ability for Spectrally Efficient, Cost Effective One-Way Voice Communications in the 930-931 MHz Band	)	File No. PP-84

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JUN 19 1992

FEDERAL COMMUNICATIONS COMMISSION
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FORMAL OPPOSITION OF MOBILE
TELECOMMUNICATION TECHNOLOGIES CORPORATION

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June 19, 1992

No. of Copies rec'd 0+5
List A B C D E

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FORMAL OPPOSITION OF MOBILE
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Mobile Telecommunication Technologies Corporation ("Mtel"), by its attorneys, herewith submits its formal opposition to the above captioned Pioneer Preference Request of Paging Network, Inc. ("PageNet").[1] The proposed VoiceNow service would use the equivalent of ten conventional paging channels (250 kHz) to "alert subscribers that a voice message has been received and store the message in the pager . . . ." According to PageNet, "[f]rom an engineering perspective, the system supporting VoiceNow services is extremely complex."

As detailed below, PageNet has failed to provide the required demonstration of technical feasibility to confirm that its basic engineering concepts could become a reality. Furthermore, its request does not entail the type of innovations or technological advances which would warrant a

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[1] See Paging Network Inc. Request for a Pioneer's Preference for Pioneering the Ability for Spectrally Efficient, Cost Effective One-Way mobile Voice Communications in the 930-931 Band, ET Docket No. 92-100, PP-84, (filed June 1, 1992) ["PageNet's Pioneer Preference Request" or "Request"].

preference in any event.[2] Accordingly, PageNet's request should be dismissed.

I. SUMMARY

In its Pioneer Preference Request, PageNet seeks to obtain exclusive nationwide rights to one fourth of the entire 930 - 931 MHz band for its proposed VoiceNow service. PageNet would use 250 kHz of spectrum to introduce a voice paging service that offers subscribers the ability to listen to stored voice pages when they want. Its request contemplates an "extremely complex" engineering plan that involves "[a] combination of simulcast paging, coupled with frequency re-use, dynamic frequency reallocation techniques and propagation modeling . . . ." Indeed, "PageNet also intends to apply digital modulation and voice compression techniques to optimize its use of the spectrum."

In support of its Pioneer Preference Request, PageNet appends a series of statements or letters from engineering consultants or vendors that purportedly confirm VoiceNow's technical feasibility. However, a fair reading of these submissions reveals that they involve (1) a simple system description (Moffet, Larson & Johnson, Inc.); (2) an expression of willingness from a software company to provide

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[2] Establishment of Procedures to Provide a Preference To Applicants Proposing An Allocation For New Services, Gen Docket No. 90-217, 6 FCC Rcd 3489 (1991).

modeling services even though the proposed application of the technology is "beyond [the company's] specific experience" (CNet); (3) a summary of radio noise measurements accompanied by a list of unsolved problems and future work projects (Trott); and, (4) a two page letter asserting on the basis of three articles in engineering literature that "this system definitely is feasible using parameters approximating those of the [Moffet, Larson, and Johnson] Report" (Keiser).

The foregoing statements and letters hardly constitute a demonstration of technical feasibility within the meaning of the Commission's Pioneer Preference rules. The absence of meaningful engineering studies, laboratory work or field tests verifying the VoiceNow system is a glaring and fatal deficiency. Its request does not address or answer major technical issues associated with the following aspects of the VoiceNow proposal:

- Deploying a four cell re-use plan operating with eight 25 kHz channels.
- Employing a 16 QAM digital modulation in a mobile environment.
- Realizing effective and practical speech encoding at 2400 bps.
- Achieving its claimed simulcast capacity.
- Obtaining meaningful increases in spectrum efficiencies through dynamic frequency allocation.
- Procuring receivers at the predicted costs.

PageNet's failure to address the technical feasibility of these essential aspects of its proposal requires dismissal of its Pioneer Preference request.

As a separate matter, PageNet has not proposed any significant innovations or technical advances warranting a Pioneer Preference in any event. The proposed frequency re-use, dynamic frequency reallocation, and receiver locating are no more innovative now than were similar concepts submitted by PageMart, Inc. two months before PageNet's first participation in this docket. Furthermore, PageNet's "propagation prediction" is derivative of a technique patented by Motorola and in use on the ARDIS system. Last, PageNet's final alleged innovation, digital voice communications, is not a breakthrough peculiar to VoiceNow or attributable to PageNet's efforts.

Finally, PageNet's proposed service is not an inherently nationwide service offering. PageNet inadequately explains why or how nationwide service is either necessary or contemplated by the VoiceNow system architecture. In fact, its demand study used to support nationwide demand "is not statistically projectable" according to its consultant. In contrast, the well documented pattern of declining marketplace demand for conventional voice paging services suggests little consumer interest in VoiceNow's core purpose. Consequently, there is no basis for awarding PageNet a

pioneer preference for the service or the efforts reflected in its Request.

II. SYSTEM DESCRIPTION

PageNet has proposed a digital voice paging system that alerts subscribers when a voice message has been received and stores that message in pagers to be replayed at the subscriber's convenience. Essentially, Pagenet proposes to accomplish this through the use of two separate messaging networks that integrate a fixed receiver network and a centralized system controller. The service, called VoiceNow, would require a total of ten 25 kHz channels for each service provider.[3] PageNet summarizes this design by stating:[4]

> From an engineering perspective, the system supporting VoiceNow Services is extremely complex. A combination of simulcast paging, coupled with frequency re-use, dynamic frequency reallocation techniques and propagation modeling underlie the system design. PageNet also intends to apply digital modulation and voice compression techniques to optimize its use of the spectrum.

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[3] Simultaneously with the filing of its Pioneer Preference Request, PageNet filed a petition for rulemaking urging the Commission to allocate spectrum for two nationwide VoiceNow type services and two local VoiceNow services. Its proposed rules would thus allow no more than four advanced messaging systems in a given market, one of which would be a nationwide system licensed to PageNet.

[4] Request at 7.

PageNet's system would consist of (1) a simulcast paging channel, (2) a subscriber's acknowledgment channel, and (3) eight message channels.[5] When a voice message is to be delivered to a subscriber, the simulcast paging channel would command the subscriber's pager to transmit a low power acknowledgement message ("ACK") so that the approximate location of the subscriber can be ascertained. PageNet postulates that the ACK will be received by at least one of a number of radio receivers blanketing the service area and forwarded to the network controller. The network controller will analyze the received signal strength, the known location of the fixed receiver, and appropriate digitized terrain data in order to determine the general whereabouts of the subscriber.

Once the approximate location of the subscriber is known, the network controller will determine which message frequency would best deliver the awaiting voice message to the subscriber. PageNet would configure the eight message channels into a four cell re-use pattern using two channels per cell. When the network controller determines which cell site is best suited to transmit the voice message to the subscriber, the simulcast paging channel will be used to once again address the subscriber's pager and command it to tune to the proper message frequency. The digitized voice message

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[5] Request, Exhibit 3 at 2.

would then be stored in the pager until the subscriber decides to replay the message.

III. PAGENET HAS FAILED TO DEMONSTRATE TECHNICAL FEASIBILITY OF ITS PROPOSED SERVICE

Under Section 1.402(c) of the Commission's Rules and the requirements set forth in the Commission's April 30, 1992, public notice, proposals for advanced messaging services seeking a pioneer's preference were required to be filed by June 1 and to include "the demonstration of technical feasibility or preliminary experimental results required to be filed as part of its request."[6] PageNet's technical feasibility demonstration consists of several exhibits including:

- An undated document entitled "Final Engineering Report" prepared by the firm of Moffet, Larson, & Johnson (Request, Exhibit 3);
- A one page graphic depicting its proposed AMS Signalling Sequence (Request, Exhibit 4);
- An undated statement from Raymond C. Trott Consulting Engineers, Inc. noting noise problems in the 930 MHz band and suggesting further avenues of inquiry (Request, Exhibit 5);
- A two page letter from Dr. Bernhard Keiser dated May 30, 1992, asserting that "digital modulation using 16 QAM is feasible to paging units in a Rician fading environment (portable pagers operating under slowly moving conditions, often indoors)" and that "the speech coding technique should be one that operates at the

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[6] Public Notice "Deadline to File Pioneer's Preference Requests 900 MHz Narrowband Data and Paging (ET Docket No. 92-100), April 30, 1992 (mimeo no. 22922).

lowest bit rate consistent with adequate intelligibility and speaker recognition. LPC [linear predictive coding] at 2400 b/s is felt to meet this requirement" (Request, Exhibit 6);

•A diagram entitled "Dynamic Frequency Allocation" illustrating the borrowing of a channel from one cell for temporary use in another cell (Request, Exhibit 7);

•A drawing illustrating the point that the "optimum message transmitter [is] not always the nearest to the subscriber" (Request, Exhibit 8);

•A two page letter dated May 29, 1992, from CNet describing CNet's propagation modeling services and offering to work with PageNet (Request, Exhibit 9); and

•A diagram summarizing how PageNet proposes that its system function in determining which message transmitter to utilize (Request, Exhibit 10).

These submissions set forth the basis for the Commission to evaluate whether PageNet has provided an adequate technical justification to warrant the tentative award of a pioneer's preference to PageNet.

PageNet's exhibits offer an overview and brief technical commentary of the service to which it would have the Commission devote the entire 930 MHz band for two nationwide and two local service providers. As a technical feasibility demonstration, however, the exhibits raise numerous concerns calling into question both the technical feasibility of the proposed service and the degree of innovation claimed by PageNet in support of its quest for a pioneer's preference. These initial issues, which should have been addressed in any technical feasibility demonstration, are summarized below.

A. PageNet Has Not Demonstrated the Feasibility of a Four Cell Re-Use Plan

PageNet's four cell re-use plan raises serious engineering issues concerning the potential for severe co-channel interference to subscribers' paging devices.[7] In an earlier analysis of a similar four cell re-use plan proposed by PageMart, Mtel demonstrated that the co-channel carrier to interferer ratio of a four cell re-use pattern was 12.93 dB for a subscriber device located at the edge of a given cell's service area.[8] Such an environment is well below the 18 dB operational standard of the cellular radio service for co-channel interference ratio. Simply put, PageNet cannot operate this system without a substantial redesign of its cellular re-use pattern.[9]

The signal-to-noise ratio of a particular channel is degraded not only by co-channel interference, but by adjacent channel interference and man-made electrical noise as well.

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[7] Attached as Figure 1 is a depiction of a wide area four cell re-use plan.

[8] Mtel Formal Opposition and Reply Comments, at 3 & A4-A9, ET Docket No. 92-100, PP-40 (filed June 1, 1992). Although PageNet intends to use the 8 message channels only in a one-way mode, this difference from PageMart's system does not affect the co-channel carrier-to-interferer ratio.

[9] While there may be modulation schemes that are more impervious to co-channel interference and could possibly operate in this environment, this is not the case with 16-QAM according to the paper by Webb, infra, n. 13, relied upon by PageNet.

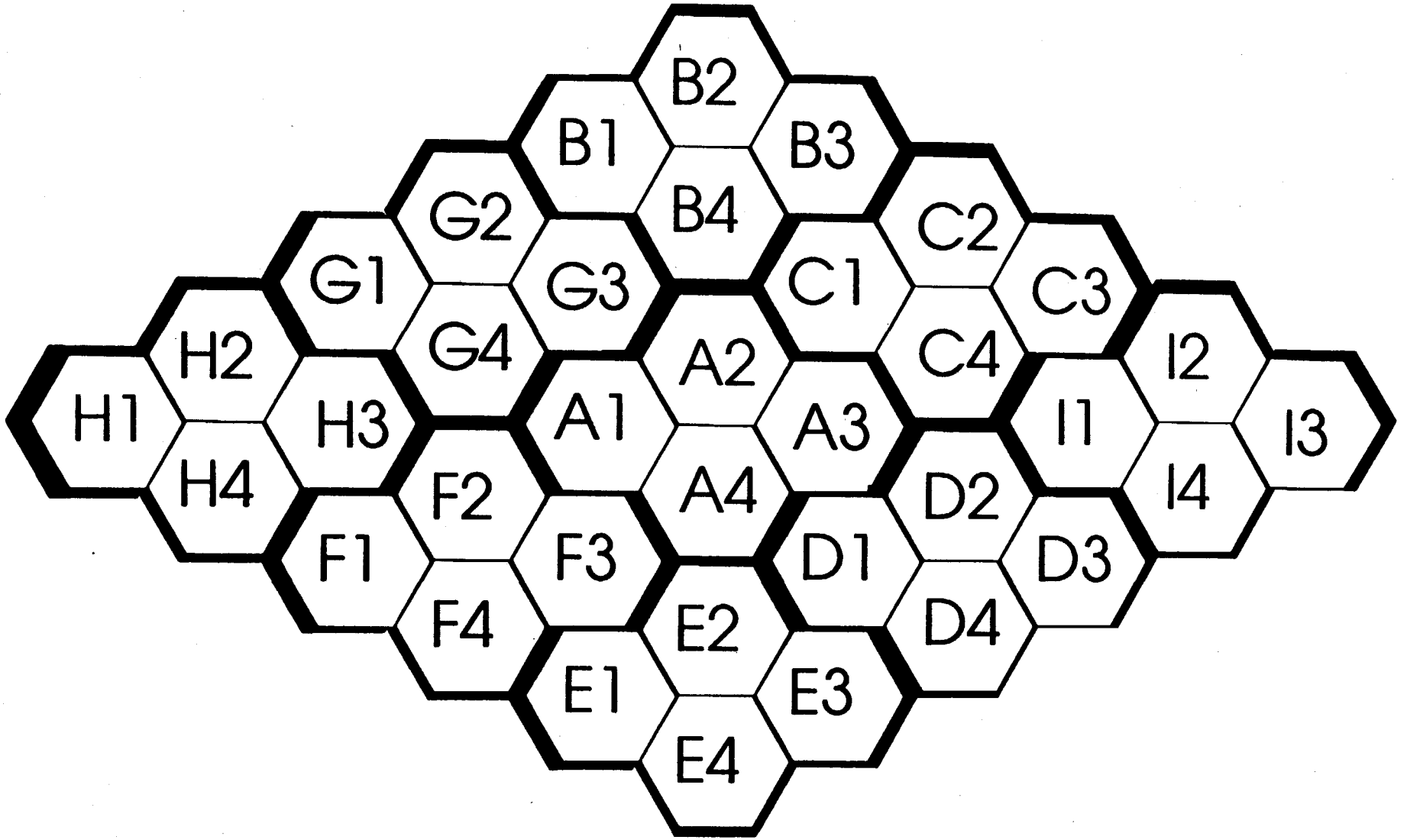

Figure 1: Four Cell Frequency Re-use

As noted in the Webb paper relied upon by PageNet,[10] a 16-QAM signal theoretically requires a high signal-to-noise ratio, on the order of 25 dB, in order to provide acceptable voice quality. Since PageNet's four cell re-use plan provides only a 13 dB co-channel carrier-to-interferer ratio at the cell's edge it appears unlikely to achieve such a high signal to noise ratio anywhere within the cell.

B. PageNet Has Not Demonstrated the Feasibility of 16-QAM Digital Modulation in a Mobile Paging Environment

PageNet relies entirely on the following statement from an engineering consultant to demonstrate the technical feasibility of using 16-QAM digital modulation for its proposed paging service:

> Digital modulation using 16-QAM is feasible to paging units operating in what probably is a Rician fading environment (portable pagers operating under slowly moving conditions, often indoors). This conclusion is based on recently reported results. [footnote omitted][11]

Under PageNet's own paradigm, applicants for a pioneer's preference must demonstrate that "it is feasible to offer these services at prices which will permit those the service

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[10] See n. 13, infra.

[11] Request, Exhibit 6, page 1.

is intended for to subscribe."[12] PageNet has failed its own requirement. Neither the above statement nor the referenced reported results[13] lead to the conclusion that the proposed modulation scheme is usable under the conditions contemplated by PageNet. In fact, the referenced papers further fuel doubts that this modulation can be successfully deployed in a paging environment. Nonetheless, the Commission should demand that a demonstration of technical feasibility include more than a mere citation to theoretical papers.

Sixteen level Quadrature Amplitude Modulation (16-QAM) is a highly complex digital modulation scheme. This system has not been used in the mobile services because of poor performance characteristics in the Rayleigh fading environment which dominates the mobile radio environment.[14]

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[12] Request at 3.

[13] Does 16-QAM Provide an Alternative to a Half-Rate GSM Speech Codex?, W. Webb, et al, Transactions of the 41st Vehicular Technological Society (May, 1991), page 511. An Analysis of Pilot Symbol Assisted 16-QAM for Digital Mobile Communications, James K. Cavers, Transactions of the 41st Vehicular Technological Society (May, 1991), page 380.

[14] Rayleigh fading is the result of out-of-phase multipath signals combining at the receiver to degrade reception severely. Higher order schemes are particularly susceptible to degradation in this environment. Higher order modulations, such as 16-QAM, are also extremely dependent upon proper phase information at the receiver. (A demodulator of a 16 level modulation is required to discriminate phase differences of a mere 22.5 degrees.) Given the phase distortions which result from multipath propagation, it is extremely problematic to design a receiver on a cost effective basis that provides such discrimination in a multipath environment. See Id. W. Webb, et al, at 511.

Although both papers cited by PageNet provide positive statements on the future of 16-QAM digital modulation for mobile applications, they are both academic research papers attempting to model the proper waveform characteristics of very robust 16-QAM signals. PageNet, however, has not demonstrated that it has had any involvement whatsoever in this developmental work nor that the proposed modulation was modeled with due consideration for the environment in which the proposed VoiceNow service would be deployed.

The referenced papers provide revealing information relative to the feasibility of PageNet's proposed system design. The article by Webb, which models 16-QAM voice coding schemes for use within PCN networks, contains a graph plotting bit error rate versus channel signal-to-noise ratio for a variety of 16-QAM modems.[15] This graph shows bit error rates on the order of 10^{-1} or worse for signal-to-noise ratios less than 20 dB. As noted supra, PageNet will have significant problems in maintaining a signal-to-noise ratio as high as 20 dB given the high levels of co-channel interference caused by its proposed use of a four cell re-use pattern.[16] Thus, its proposed modulation scheme will likely be fraught with entirely unacceptable error rates.

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[15] Id. at 512.

[16] See p. 9 supra.

In sum, PageNet has not demonstrated that 16-QAM modulation will perform as required, much less at costs that the subscriber is willing to pay. Although theoretical work is being performed to analyze the performance of this technology in the mobile environment, this does not necessarily translate to commercial grade equipment for noisy environments which will typify PageNet's proposed operations. In its June 1 filing, PageNet did not reveal any direct involvement in any development of this technology or any intention to commence a program of scientific development and research into the issue. For these reasons, PageNet has not fulfilled the requirement to show that 16-QAM digital modulation is technically feasible and that PageNet warrants a pioneer's preference for proposing to use it.

C. PageNet Has Not Demonstrated That Speech Encoded at 2400 Bits Per Second is Feasible and Effective

PageNet has proposed to encode speech using linear predictive coding (LPC) techniques operating at 2400 bits per second (bps). This is based on the following discussion from its consultant:[17]

> The speech coding technique should be one that operates at the lowest bit rate consistent with adequate intelligibility and speaker recognition. The lowest rate not only minimizes channel occupancy, but

[17] Request, Exhibit 6 at 1.

> also minimizes storage requirements. LPC at 2400 b/s is felt to meet this requirement.

PageNet further remarks that "this bit rate minimizes channel occupancy and storage requirements while still achieving the high degree of intelligibility and speech recognition that PageNet perceives as necessary to meet user requirements."[18]

The ability to encode speech at such a low data rate and be able to retain intelligibility and speaker recognition is highly suspect. This very month, the IEEE published a paper which states:

> Speech compressed to 2.4 kb/s provides a high level of intelligibility. However, speech quality, naturalness, and speaker recognizability are all poor at this bit rate.

and,

> At 8 kb/s, which is the bit rate chosen for the first-generation digital cellular telephony in North America [footnote omitted], speech quality is high although significantly lower than that of the uncoded telephone-band signal.[19]

Obviously, the above IEEE paper is a direct contradiction to PageNet's statements about the quality of this technique. Moreover, after years of analysis and experimentation, the cellular radio industry only very

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[18] Request at 18.

[19] Nikil Jayant, "Signal Compression: Technology Targets and Research Directions," IEEE Journal on Selected Areas in Communications, Vol 10. No. 5, June 1992 at p. 800.

recently adopted the use of a 8000 bit per second data rate for speech encoding. PageNet, on the other hand, provides no evidence that it has researched linear predictive encoders operating at 2400 bps and found their performance acceptable for use in a consumer-based mobile service. As such, its unsupported claims fail to warrant a pioneer's preference.

D. PageNet Has Miscalculated the Capacity of Its Simulcast Paging Network

PageNet claims that its simulcast channel can support 330,600 users. This calculation, however, apparently fails to consider the disparate data rates of the outgoing and incoming messages. As proposed in its Request, PageNet's design should result in a large number of colliding subscriber acknowledgements (ACKs) at the receiver thus requiring numerous retransmissions that threaten to significantly reduce the actual capacity of the simulcast paging network.

PageNet shows that its outgoing simulcast paging channel transmits 191 ERMES codewords per second.[20] In determining the capacity of its outgoing simulcast paging channel, PageNet assumes that all subscribers will be receiving a voice page on the messaging channel. Thus, two pages will be required over the simulcast channel -- one to command the

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[20] See Request, Exhibit 3 at 17.

pager to generate an ACK and the other to command the pager to switch to a message channel. Each of these pages will use four codewords.[21] Such activity results in nearly 24 messages per second (191 codewords per second divided by 8 codewords per message).[22] Twenty-four messages means each outgoing message occupies 41.6 milliseconds.

PageNet also states that its ACK messages are pulse transmissions that occupy 200 milliseconds.[23] This pulse rate is therefore five times slower than the rate of messages transmitted on the simulcast paging channel. If the simulcast pages are sequentially signalling pagers in the same approximate area, the resultant ACKs will collide at the receiver sites causing harmful interference and destroying the identification information contained in the ACK. The resulting retransmissions of the original messages will reduce system capacity.

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[21] Id.

[22] Another way to solve for the number of messages per second is to use PageNet's formula for determining channel capacity:

$$P = 3600\ (N/BHCR)$$

where P is the number of users (total capacity), N is the number of messages per second, and BHCR is the Busy Hour Call Rate. Substituting PageNet's numbers for P (330,600) and BHCR (0.26) and solving for N yields approximately 24 messages per second. See Request, Exhibit 3 at 16.

[23] Request, Exhibit 3 at 7.

While the distribution of pages over a wide service area may mitigate the effects of this design flaw in some areas, this does not address the potential congestion that could occur in very densely populated areas such as Manhattan or Los Angeles. At occupancy rates anything near capacity, the inadequate capability of PageNet's receiver network calls into question the feasibility of the overall network.

E. PageNet Has Not Demonstrated That Dynamic Frequency Allocation Would Provide Any Meaningful Increases in Spectrum Efficiency

PageNet expects to be able to reallocate frequencies to cells with increased demand in order to increase system capacity.[24] PageNet provides little analysis on how it intends to accomplish this task or any analysis on the efficiencies it intends to achieve in this manner. In a four cell re-use scheme, however, when a channel is borrowed from the adjacent cell within the borrower's cell group, the channel is precluded from being used in all adjacent cell groups. See attached Figure 2. PageNet does not discuss how this relationship affects the overall efficiency of its dynamic frequency reallocation proposal.

Instead, PageNet depicts its vision of dynamic frequency reallocation in Exhibit 7 to its Pioneer's Preference Request. The picture in this exhibit shows a channel from

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[24] Request at 19.

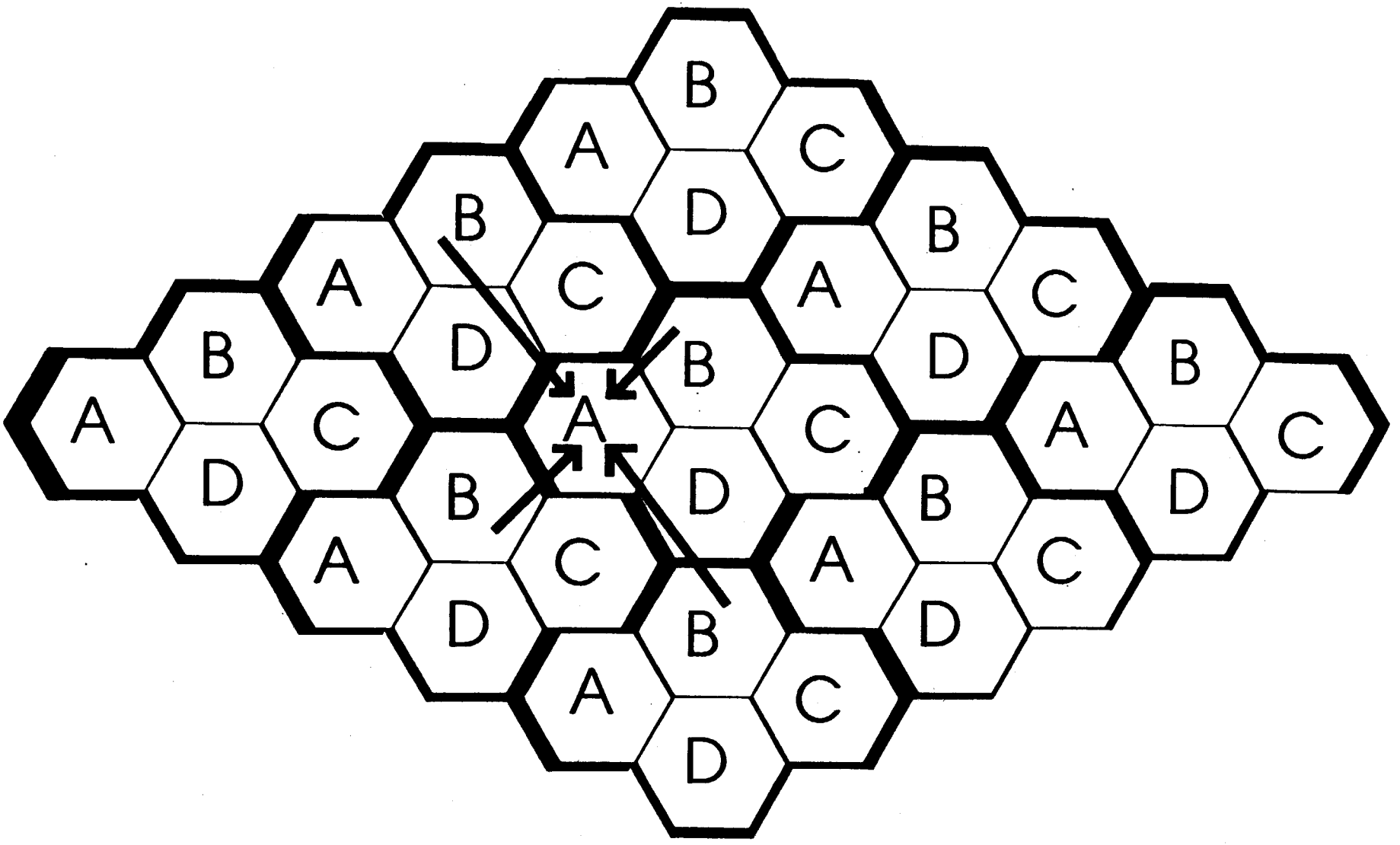

Figure 2: Cell Borrowing Requires Precluding Use of the Channel in 4 Cell Groups

Cell D (channel M3) being reallocated to the adjacent cell, Cell A. Although this picture contains a total of seven cells, Cell D's channel group (channels M3 and M4) is not shown as being re-used by any other cell.[25] An accurate depiction of a four cell re-use pattern would necessarily show that channels M3 and M4 are assigned to another cell abutting Cell A. Therefore, a reallocation of channel M3 from Cell D to Cell A would preclude the other adjacent cells to Cell A from using channel M3. Again, PageNet has failed to address fundamental design issues related to cellular radio networks. As such, its proposed dynamic frequency allocation scheme does not merit a pioneer's preference.

F. PageNet Does Not Demonstrate That It Can Provide Pagers With the Necessary Features in a Cost Effective Manner to Support VoiceNow Service

PageNet provides no evidence that manufacturers can design pagers to suit its needs on a cost efficient basis. PageNet merely informs the Commission that it has "assurances" from manufacturers that pagers can be built addressing its needs without adding significantly to the size

[25] On the other hand, channel group M7 and M8 are re-used three times and channel group M5 and M6 are re-used twice.

of the pager for an additional $100.[26] This statement contains no supporting evidence to verify this claim.

The pager required for VoiceNow service would be a conventional transmitter/receiver with an unconventional (as far as low cost portable devices are concerned) linear 16-QAM receiver. This is extremely new technology to land mobile communications and has not been previously used in paging applications. The use of a coherent demodulation scheme requires that significant technical challenges be overcome and may even require the use of pilot tones or symbols in the radio channel format which will add further complexity to the receiver design. The design analysis for such an approach is entirely theoretical at this time.[27] Also, as PageNet notes, receivers in this band will be subject to adjacent channel interference from high power paging base stations.[28] Providing sufficient protection from adjacent channel sideband noise will be extremely difficult, if not impossible, using conventional linear amplifier technology for a 16-QAM signal in a 25 kHz channel.

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[26] Request at 21, 32.

[27] See Cavers, n. 13 supra.

[28] Request, Exhibit 5. This is the only indication of any experimental effort. It consists of a summary of noise measurements taken on unspecified date(s). While the information reported is relevant, it is hardly indicative of any pioneering effort leading to an innovation. Noise measurements are a standard technique for characterizing receiver sites.

Therefore, Mtel is very skeptical that a pager can be designed to satisfy all of VoiceNow's requirements at a cost of an additional 100 dollars, especially when the unit under consideration involves a theoretical modulation scheme. PageNet's feasibility analysis on this matter is encapsulated by the comment that "it should be possible to build the pager using VLSI chips."[29] This is wholly inadequate for demonstrating the technical feasibility of its claims.

G. PageNet Has Not Demonstrated the Feasibility of Its Message Channel Assignment Technique

PageNet claims credit for proposing to implement a method of selecting the best messaging channel on which to transmit the voice page.[30] As set forth in the Moffet, Larson & Johnson Final Engineering Report, this technique relies on analysis of the ACK signal from the pagers and would work as follows:

> The computerized network control center then analyzes the signal to insure that it is coming from an authorized pager, and compares the signal strength and other parameters received from various receivers to determine the approximate geographic location of the pager. Each ACK receiver will forward all received data to the Network Controller, accompanied by a measure of the signal strength. Thus, for each acknowledgement transmission from a pager the network will have data from one or more receivers with varying signal strengths. The Network Controller will use this information to estimate the location of the pager as

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[29] Request, Exhibit 6 at page 2.

[30] Request at 24 - 25.

> follows: Digitized terrain and obstacle information for the coverage area of each receiver can be used to estimate the distance from that receiver as a function of the received signal strength. The combination of this information from whatever number of receivers report the acknowledgement are used to determine the location of the pager. That information is then referenced to another table of Message Transmitter coverage predictions as described above in [the] "Paging Control" [section of the Moffet, Larson & Johnson report]."[31]

According to PageNet's consultants, the information in its coverage database would be "based initially on the theoretical design with further adjustment and 'fine tuning' based on experience."[32]

Apart from its description and an offer of assistance from a software company, which admits that the integration of its propagation prediction techniques in such an application is "beyond [its] specific experience," PageNet has failed to address the feasibility of its proposed method.[33] Furthermore, there are certain other inherent problems PageNet fails to address. For example, PageNet proposes to rely in part on the ability of the system to measure signal strength at various receivers. It does not address the time

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[31] Request, Exhibit 3 at 10.

[32] Id. at 11.

[33] Request, Exhibit 9 (stating "[w]hile this application of technology is beyond CNet's specific experience, we are capable of modeling the predicted performance of a 930 MHz network of transmitters - taking into consideration terrain, foliage, buildings, and actual field measurements - to determine an optimum message transmitter for a given location.").