Mtel believes 50 kHz channels are necessary to support the expected demand for NWN service. Due to the 3,000 baud limitation on signaling rates for simulcast systems,[17] Mtel believes that a commercially feasible NWN system will be required to transmit in excess of 3 bits per baud interval. Enhanced multitone modulation schemes can achieve the required data rate by utilizing combinations of 8 tones. However, to permit efficient demodulation without cross-interaction between tones and their detectors (the "orthogonal" property),[18] the spacing of the tones should be equal to the baud rate; *i.e.*, 3 kHz between each tone pair for a 3,000 baud system. In addition, for multitone on/off keying ("MOOK") modulation schemes, additional spectrum also is required for a "pilot" tone in the center of the tone band. Thus, as shown in Figure 1, a total of 30 kHz is required in the pass band, leaving 10 kHz guardbands on either side. At 24,000 bps, such a system has a spectral efficiency of 0.48 bits/Hertz.

Although the use of a 10 kHz guardband initially may appear to be excessive in an era of narrowband systems, extended guardbands are necessary for enhanced multitone modulation systems due to secondary out of band intermodulation products. Even though these intermodulation products typically are 30 dB lower than the power level of the tone signals, extensive filtering is nevertheless required to decrease out of

---

[17] The interaction between baud rate and simulcast operation is fully developed in Appendix B.

[18] For a general discussion of orthogonal frequency shift keying, see E. Arthurs and H. Dym, "On the Optimum Detection of Digital Signals in the Presence of White Gaussian Noise--A Geometric Interpretation and a Study of Three Basic Transmission Systems," *IRE Transactions on Communications Systems* at 336 (December, 1962); *Reference Data for Engineers: Radio, Electronics, Computer, and Communications* at 24-10, Howard W. Sams & Co. (7th Ed. 1985).

band emissions to acceptable levels. Using filters with a shape factor of 1.6, an 8 tone enhanced multitone modulation system will require a guardband of 9 kHz.[19] Because neither the actual baud rate nor the actual transmission protocol has been determined for any particular NWN licensee, however, a 10 kHz guardband should be allocated.

V. THE COMMISSION SHOULD DEVELOP NWN LICENSING PROCEDURES AND STANDARDS THAT FOSTER COMPETITION, PROMOTE INDIVIDUALITY AND DISCOURAGE SPECULATION

A. NWN Licensing Procedures and Standards Should Accommodate Multiple Providers

The public benefits of competition should be available in the NWN service. Accordingly, Mtel believes the FCC should develop licensing procedures and standards that accommodate multiple providers. Mtel does not believe a so-called "natural monopoly" exists for this service. Indeed, Mtel submits that spectrum resources can support three, and a minimum of two, NWN providers in competition with each other.

---

[19] Although Mtel will experiment with other modulation forms including direct FM, it appears that the proposed enhanced multitone modulation schemes require the use of linear Class A amplifiers. These amplifiers will require filters capable of dissipating a great deal of heat, potentially requiring extensive cooling systems. With the large number of transmitters required in the NWN system, the costs of such "broadcast-type" installations could quickly render NWN prohibitively expensive if shape filters tighter than 1.6 are required (the "shape factor" of a filter is the total bandwidth required to achieve an acceptable level of attenuation divided by the passband). For a passband of 30 kHz, use of a 1.6 shape factor filter will attenuate the signal to acceptable levels 24 kHz from the channel center ((30 kHz x 1.6) / 2).

Through such competition, consumers would receive high quality service at the lowest possible cost.[20]

Mtel also believes that competition would be enhanced by permitting licensees to opt for non-common carrier status, similar to a scheme adopted for Multipoint Distribution Service licensees under Part 21 of the Commission's Rules.[21] Because carrier would have the option, however, all applications would be processed under Part 22 rules and non-common carrier NWN licensees would be expected to comply with all NWN regulations contained in the proposed Subpart N of Part 22, including all relevant common carrier licensing qualifications.[22]

B. NWN Rules Should Provide Licensees Flexibility to Design Unique Systems

In Appendix A, Mtel has provided a model system demonstrating NWN's potential, feasibility and capacity. Mtel does not believe, however, that licensees should be restricted to the use of synchronized simulcast networks, enhanced multitone modulation, or the transmission protocols Mtel has developed for its own use. Instead, the NWN rules should be crafted to allow individual system operators flexibility to

---

[20] The benefits of a competitive market structure have been noted by the Commission on numerous occasions. *See Cellular Communications Systems*, 86 F.C.C.2d 469, 474 (1981); *Multipoint Distribution Service*, 45 F.C.C.2d 616, 622 (1974).

[21] *See* proposed rule § 22.1201. An applicant opting for non-common carrier status nonetheless should be required to comply with all common carrier qualification and licensing requirements, *e.g.*, FCC Form 430 requirements.

[22] 47 C.F.R. § 21.900 (1991).

design innovative systems based upon each provider's own experience and technical expertise. Mtel proposes some constraints, however, to limit interference to adjacent services and to ensure that NWN operators will design systems consistent with the market demands NWN was created to serve.

First, systems should be inherently nationwide in scope. As per proposed rule 22.43(f), licensees, at a minimum, should be required to serve all top-10 MSAs within 18 months of license grant, and the remaining MSAs according to the following schedule:

	Total MSAs
Year 2:	30
Year 4:	60
Year 6:	100

In each MSA, service would be established if: (1) a licensee provided 43 dBu forward channel coverage to 75 percent of the MSA's geographic area or total population;[23] and, (2) a licensee provided a minimum of four base receivers per base transmitter for reverse channel coverage.

Second, systems should be designed as fully two-way, with portable user terminals capable of initiating substantial data transfers. Although licensees should be allowed initially to provide one-way services and limited "answer-back" service, fully

[23] Coverage should be calculated using the 450 MHz curves in accordance with "Technical Factors Affecting the Assignment of Facilities in the Domestic Land Mobile Radio Service," Roger B. Carey, FCC Rpt No. R-6406 (June 24, 1964) ("*Carey Report*"). *See* proposed rule 22.1203.

operational two-way transfer capability should be available no later than 24 months after initiation of service within an MSA.[24]

Third, NWN systems should be digital transmission systems, since NWN is designed to address the needs of the nation's portable data users. In proposed rule 22.1205, Mtel has left space for an appropriate emissions designator for the proposed NWN service, to be determined during the rulemaking process. Mtel is reluctant to specify a particular emissions designator at this time, since it believes the rules should accommodate alternatives to its specific proposal that may entail other modulation techniques and channel usage.

Fourth, as described in proposed rule 22.1204, NWN base systems should be exempted from any height limits and subject to a maximum power of 3500 watts ERP, since there will be no co-channel licensees.[25] Portable user transmitters should be limited to a maximum power of 7 watts ERP in order to facilitate an environment in which both portable and vehicular mobiles can be accommodated.

Finally, NWN systems should be designed to limit intersystem interference. Specific limitations on out of band emissions, of course, will vary somewhat depending upon neighboring allocations. Initially, however, Mtel suggests adoption of the following emissions mask, specified in proposed rule 22.1206:

---

[24] *See* proposed rule 22.43(f)(2).

[25] A similar rule has been approved for nationwide paging licensees. *Compare* 47 C.F.R. § 22.505(c)(2), proposed rule 22.1204.

For 0 kHz $\leq f_d \leq$ 17.5 kHz: $A(f_d) = 0$ dB;

For 17.5 kHz $\leq f_d \leq$ 22.5 kHz:

$$A(f_d) = 83 \log_{10}((f_d - 12.5 \text{ kHz})/5)$$

For 22.5 kHz $\leq f_d \leq$ 75 kHz, the lowest of:

$$A(f_d) = 116 \log_{10}((f_d - 12.5 \text{ kHz})/6.1) \text{ dB; or}$$
$$A(f_d) = 50 + 10 \log_{10}(P) \text{ dB; or}$$
$$A(f_d) = 70 \text{ dB.}$$

For 75 kHz $\leq f_d \leq \infty$, the lowest of:

$$A(f_d) = 43 + 10 \log_{10}(P) \text{ dB; or}$$
$$A(f_d) = 80 \text{ dB.}$$

Where:

f_d =	Offset from channel center in Hertz.
$A(f_d)$ =	Required attenuation in dB at offset f_d from the channel center.
P =	Unmodulated carrier output power in Watts.

This mask corresponds to the emissions mask requirements in Section 22.106(b)(2) of the Commission's Rules for wide area digital systems operating in the 929.0 to 932.0 MHz bands except that the mask has been displaced by 12.5 kHz to reflect a 50 kHz NWN channel.[26]

---

[26] 47 C.F.R. § 22.106(b)(2) (1991).

C. The Commission Should Adopt Rules that Discourage the Filing of Speculative Applications

Mtel shares the Commission's opinion that license speculation should not be tolerated.[27] Speculators needlessly delay public availability of new services and drive up the ultimate cost of service to consumers by increasing carriers' fixed initial investment costs in obtaining licenses. Accordingly, Mtel has proposed licensing rules designed to discourage the filing of speculative applications. Mtel's rules, described below, will limit speculation by (1) adopting stringent threshold requirements to reduce the number of "lottery ticket" applications; (2) awarding licenses to the best qualified applicants based upon expedited comparative proceedings; and (3) reducing the speculative value of NWN licenses through antitrafficking rules.

1. The Commission Should Adopt Stringent Threshold Filing Requirements

The first step in Mtel's proposed licensing scheme would require applicants to pass a strict threshold qualifications test before further comparative consideration.[28] Because Mtel believes that NWN may not be a profitable service in its first two years of operation, Mtel urges the Commission to require applicants to demonstrate sufficient

---

[27] *See* Order, *Acceptance of 220-222 MHz Private Land Mobile Applications*, DA 91-647 (Released May 24, 1991), (discussing how in a few weeks, over 50,000 applications were filed for 220 MHz land mobile licenses).

[28] *See United States v. Storer Broadcasting, Co.*, 351 U.S. 192, 205 (1956) (the FCC may establish threshold standards that applicants must satisfy before they are entitled to be eligible for comparative consideration).

net liquid assets to construct all necessary benchmark systems and provide service for two years.[29] As the Commission noted when initially licensing cellular radiotelephone providers, for new services with only a limited number of carriers that require highly sophisticated technology, assurances of adequate financial resources are critical.[30] Accordingly, since any estimates of operating revenues are likely to be speculative, applicants should not be entitled to rely upon revenues derived from proposed NWN operations in the financial qualifications demonstration.

Second, Mtel believes the Commission should require applicants to commit to the provision of nationwide service. Specifically, the Commission should require that applicants commit to serving the top 100 MSAs in accordance with the benchmark schedule specified in proposed rule 22.43(f). Applicants should specifically detail plans for serving each of the MSAs necessary to meet the two year benchmark detailed in proposed rule 22.43(f), with adequate assurances of site availability. Applicants proposing systems using zoning techniques also should commit to establishing initial service in at least two zones.

Third, Mtel believes the Commission should establish strict technical qualifications requirements for applicants. Such qualifications should include, but not be limited to, experience with mobile radio and messaging technology.[31] The

---

[29] *See* proposed rule 22.1217.

[30] *Cellular Communications Systems*, 86 F.C.C.2d 469, 502-03 (1981).

[31] *See* proposed rule 22.1213(a)(11).

requirements should be specified so that the vast majority of technical expertise must come from within the applicant's organization, so as to discourage speculators with so-called "paper" companies. Applications also should contain a certification that any engineering was independently prepared for a single applicant's use and will not be shared with other applicants.[32]

Finally, applicants should be required to certify, under penalty of perjury, that they have not filed the application for speculative purposes and that they intend to construct and operate the system as proposed.[33]

2. The Commission Should Use Streamlined Comparative Hearings to Award NWN Licenses

Because it is by far the least precise method of granting licenses, and because recent experience has shown that it encourages speculative applications,[34] Mtel strongly opposes use of lottery procedures to award licenses. Mtel has proposed an expedited procedure for comparative hearings that will permit an adversarial inquiry into each applicant's qualifications without delaying service to the public.[35] Mtel also

---

[32] *See* proposed rule 22.1213(a)(3).

[33] *See* proposed rule 22.1213(b)(2).

[34] As noted in footnote 27, *infra*, over 50,000 applications were filed for 220 MHz land mobile licenses.

[35] *See* proposed rule 22.1216(d).

has proposed specific comparative criteria for evaluation, including a provision for recognizing a duly awarded pioneer's preference.[36]

Under Mtel's proposed application processing rules for the NWN service, the Commission would open a one day filing window for initial applications. For these initial applications, a specific frequency need not be requested and the Commission may select from among available frequencies for any licensee. If any frequencies remain after initial applications are granted or dismissed, other frequency specific applications will be accepted on a first-come, first-served basis after the close of the initial filing window.

Applications would be processed through the threshold criteria prior to being placed on public notice as accepted for filing. Minor errors would be correctable by amendment, as long as the amendment is tendered within 30 days of receiving notice of an error or omission. The Commission would designate by public notice all mutually exclusive applications that are accepted for filing.

The procedures for conducting prehearing conferences, petitions to deny, limited discovery, the filing of direct and reply cases, and the conduct of the hearing itself, are detailed in Appendix C, proposed rule 22.1216. Briefly, proposed rule 22.1216 describes a controlled format for allowing parties discovery without unduly delaying ultimate grant of licenses, based upon the comparative procedures for selecting cellular

---

[36] *See Establishment of Procedures to Provide a Preference to Applicants Proposing an Allocation for New Services*, 6 FCC Rcd 3488 (1991). Mtel is filing a request for a pioneer's preference in the NWN service concurrently with this petition.

licensees contained in Section 22.916 of the Commission's Rules and modifications developed to expedite comparative hearings for broadcast applicants in GEN Docket 90-264.[37] In ordinary cases under rule 22.1216, the ALJ will issue a decision within ten months of the public notice accepting mutually exclusive applications for filing.

Proposed rule 22.1216 also sets forth comparative criteria by which applications will be judged. The comparative criteria enumerated include:

- the number of MSAs in which service will be provided and the MSA populations;
- the geographic area of coverage proposed;
- the number of portable user terminals to be served;
- the system architecture and the technologies the system will utilize;
- the amount of actual developmental effort and experimental verification undertaken by the applicant to validate the proposed system; and,
- the applicant's experience in operating wide area communications systems.

Using these criteria and Mtel's expedited hearing procedures, the Commission will ensure that only qualified and dedicated applicants are selected to receive licenses and that NWN service to the public will not be delayed.

---

[37] *See* 47 C.F.R. § 22.916 (1991); Proposals to Reform the Commission's Comparative Hearing Process to Expedite the Resolution of Cases, 6 FCC Rcd 157 (1990) (as corrected by errata issued June 6, 1991).

3. The Commission Should Adopt Strict Antitrafficking Rules

Mtel proposes below a number of rules intended to limit the speculative value of NWN licenses. By limiting the ability to transfer NWN licensees, Mtel hopes to discourage those entities from filing that do not actually have an interest in constructing and operating NWN systems.

First, Mtel proposes a strict ban on the sale of unconstructed systems. Because the application thresholds are tailored to ensure the ability of an applicant to meet the two year construction benchmark listed in proposed rule 22.43(f), no sale of any system should be allowed prior to passing this benchmark. By requiring an applicant to fulfil its promise of service, the Commission will discourage filers who are not dedicated to provision of NWN.

Second, Mtel proposes a rule limiting applicants to less than a 1 percent interest in another mutually exclusive application, except that interests of less than 5 percent in publicly traded corporate applicants would be permitted.[38] Such a rule would lend flexibility to publicly traded companies that may not be able to ascertain whether *de minimis* shareholders were applying for a license, while preventing any application pools from filing multiple applications.

---

[38] Similar rules were adopted for the licensing of cellular providers for the RSAs. *See* 47 C.F.R. § 22.921 (1991), proposed rule 22.1212.

VI. CONCLUSION

Mtel's proposed NWN service is needed now to provide adequate two-way data transfer capability to portable digital devices. As laptop and palmtop computers continue to proliferate and the installed base of RF compatible devices increases, the ability to transfer data using a ubiquitous, nationwide transmission medium will be critical to realizing the promise of these technological advances. NWN, with its open multilayer public interface and its ability to expand gracefully to meet future demand, ideally is suited to satisfy this demand.

As Mtel's innovative model NWN system illustrates, NWN services can be made available in a modest spectrum allocation. NWN is not an adjunct, complementary, or stopgap service. Rather, it is designed to provide a wide range of two-way data transfer services efficiently and economically. For these reasons, Mtel

respectfully submits that the public interest would be served by expeditiously initiating a rulemaking to examine fully the potential of NWN.

Respectfully submitted,

MOBILE TELECOMMUNICATION
TECHNOLOGIES CORPORATION

By: Richard E. Wiley

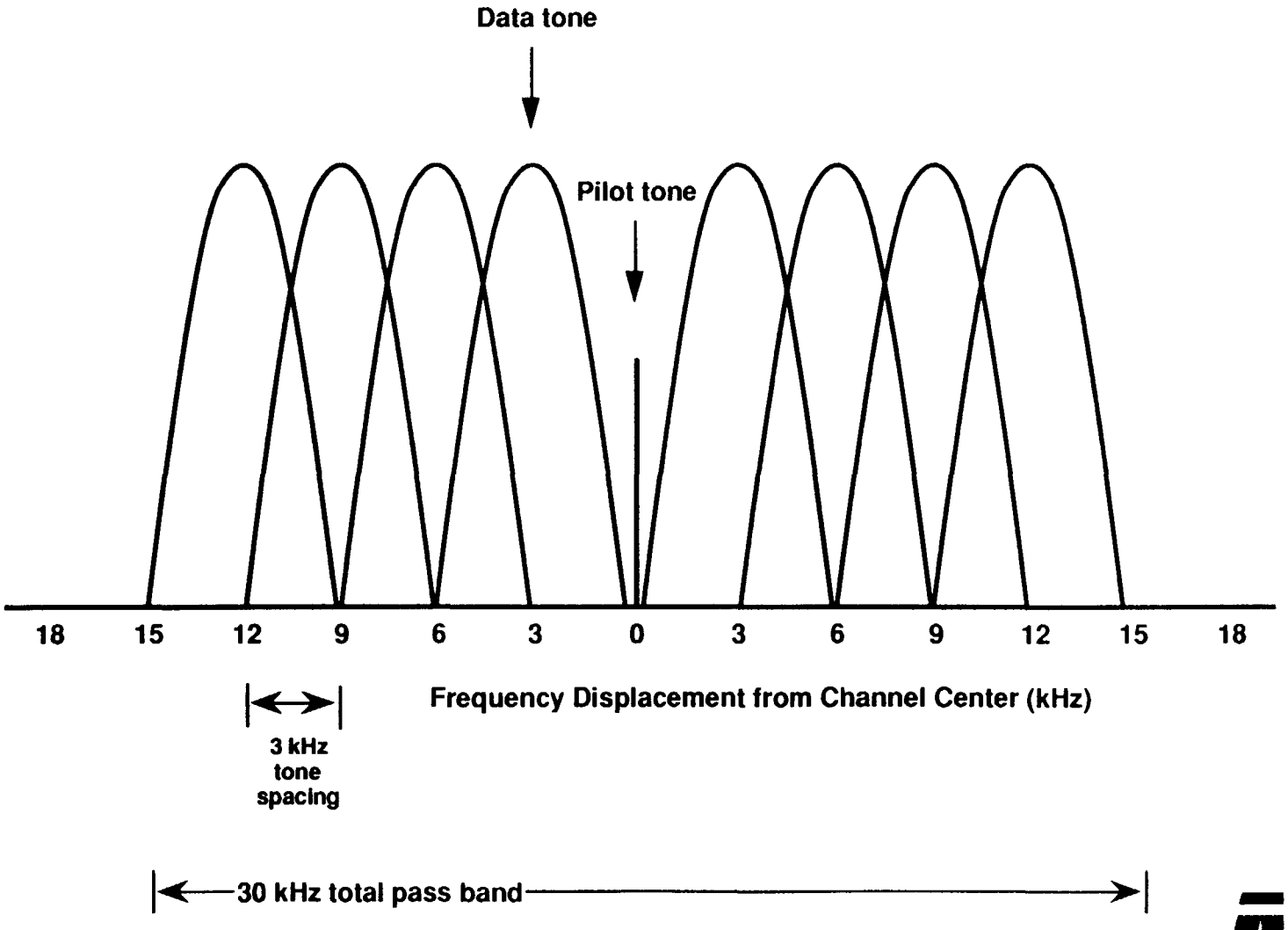
Richard E. Wiley
R. Michael Senkowski
David E. Hilliard
Eric W. DeSilva
of
WILEY, REIN & FIELDING
1776 K Street, N.W.
Washington, D.C. 20005
(202) 429-7000

Its Attorneys.

Dated: November 12, 1991

FIGURE 1

Passband Requirements for 8 tone MOOK



Mitel

A

APPENDIX A

Mtel's Model NWN System Architecture

Mtel has undertaken an aggressive program of development to create an economically feasible NWN system prototype, as described herein. Utilizing its own extensive resources and experience in high technology communications systems as well as recognized experts in modulation, multiple access protocols and manufacturing, Mtel believes it has developed a versatile, intelligent messaging system that will satisfy a substantial public demand for the foreseeable future. Through a concurrently filed experimental license application, Mtel intends to complete the final stage of its development efforts, verification of the actual field performance.

However, because Mtel's development efforts have gone well beyond the current state-of-the-art, Mtel intentionally has remained open to engineering alternatives to each of its innovations and will finalize its proposal only when the performance of each variation has been rigorously tested in the real world. Accordingly, this appendix describes only a single variation from among a number of possible NWN system implementations. Mtel believes that the system described herein is a feasible model that accurately portrays the capabilities of NWN service.

As currently envisioned, Mtel's model of the forward channel portion of NWN (base to user terminal transmissions) is a satellite-fed nationwide simulcast network relying on synchronized wide area transmitters for terrestrial coverage (see Figure A1). Because NWN user terminals are expected to operate under power constraints limiting effective radiated power, however, Mtel's NWN receiver network for the reverse

channel portion of NWN (user terminal to base transmissions) necessarily must have smaller service areas. For initial planning purposes, a base station is assumed to provide reliable service to the 43 dBu contour calculated using the *Carey Report*. As described below, separate innovative protocols have been developed both for the forward and reverse channels to maximize overall efficiency.

I. FORWARD AND REVERSE CHANNEL SIMPLEX OPERATION

Mtel's NWN system will provide both forward and reverse channel capacity from a single 50 kHz allocation using time division techniques. Mtel's system periodically will cycle through forward transmission, shutdown, and reverse transmission phases. Within each cycle the specific quantity of time devoted to forward or reverse transmissions is set dynamically to compensate for variations in traffic loading conditions.

Mtel's scheme for providing efficient simplex operations relies on precise system synchronization.[1] During the start of each forward transmission, the system transmits certain system information including, *inter alia*, when the reverse channel phase of the cycle will start. Thus, each user terminal is able to calculate when its particular transmissions on the reverse channel cycle should occur independent of the time required to shut down the network transmitters. Consequently, as technology

---

[1] Each base station will be locked to an external time standard.

improves and the network shutdown time is decreased, efficiency of Mtel's NWN system will increase.

Notably, as described further in the section detailing terminal to base transmissions, each forward subcycle from the NWN system schedules the reverse channel transmissions that will occur within the same cycle. This dynamic scheduling pattern contributes significantly to NWN's spectral efficiency and allows NWN a great deal of flexibility to deal with variations in loading conditions. The expense of providing additional intelligence in the network is a small cost to pay to achieve increased flexibility and efficiency. Mtel believes this investment will be worthwhile since the network can be upgraded as the cost of computing power decreases.

II. FORWARD CHANNEL TRANSMISSIONS IN MTEL'S MODEL NWN SYSTEM

The heart of Mtel's model NWN system is the satellite-fed nationwide simulcast network (see Figure A2). A central control facility will combine forward channel messages with synchronization marks and transmit a constant data stream to a satellite with national coverage. The satellite will retransmit the information to individual wide area base station transmitters across the country. These wide area transmitters will send message data to individual user terminals slaved to the base station transmitters, which in turn are to be slaved to the satellite synchronization marks.

A. Mtel's National Simulcast Provides an Efficient Transmission Method for Forward Channel Messaging

Until now, simulcasting was not a suitable transmission vehicle for high bit rates (4,800 bps and above) due to the limited minimum baud interval, as described in Appendix B.[2] Most simulcast one-way paging networks, in fact, operate at speeds of 1,200 bps or less.[3] ERMES, the fastest commercially contemplated simulcast technology until now, will only operate at a top speed of 6,250 bps.[4] Due to the limited throughput of these systems, two-way services generally have not utilized simulcasting. Mtel, however, employs three innovations to raise the output capacity limits previously contemplated for simulcasting:

- Mtel will use enhanced multitone modulation to increase the net forward channel capacity of the system.
- Mtel will use adaptive zoning to increase system capacity by simultaneously communicating to a number of user terminals located in separate areas.
- Mtel will use variable length batching to accommodate statistical variations in forward channel traffic.

---

[2] Effects caused by local propagation characteristics and phase alignment of various transmitters effectively limit the ultimate baud rate of simulcast systems. Accordingly, capacity increases have been derived from increasing the number of bits transmitted per baud interval using advanced multitone modulation and capacity re-use through an adaptive zoning technique. An explanation of the limits of current baud rates for simulcast systems, and a comparison of the efficiency of NWN versus cell based re-use schemes is contained at Appendix B.

[3] Mtel, however, has recently pioneered ways to increase this speed to 2,400 bps. *See Telocator Bulletin*, Vol. 91 No. 32, p. 2 (August 11, 1991).

[4] The planned ERMES (European Radio Messaging System) is to be implemented in Europe on VHF frequencies.

As described further in Appendix B, simulcasting has several important advantages. First, it improves the probability of reception by establishing unbroken coverage of large areas (thousands of square miles).[5] Second, simulcasting obviates the need for mutually exclusive frequency or time slots on adjacent transmitters -- as used in cell based re-use networks. This avoids capacity decreases necessary to protect one cell's transceiver from another. Third, simulcasting improves coverage continuity and building penetration because signals emanating from dispersed transmitters tend to fill in holes caused by shadowing or multipath. Fourth, simulcasting permits extremely rapid deployment of additional transmitters, since complex coordination within a system to integrate capacity schemes is unnecessary. Finally, simulcast systems have been proven in the paging industry as robust and cost effective.

B. Mtel's Use of Innovative Enhanced Multitone Modulation Technology Significantly Increases Total Forward Channel Throughput

The forward channel throughput is critical to the success of Mtel's NWN system since the forward channel must deliver base to user terminal message data in addition to extensive scheduling information to support reverse channel transactions. Consequently, Mtel has aggressively pursued advances in modulation technology in order to support the expected heavy use of the NWN forward channel.

---

[5] As noted in Appendix A, § II.C, *supra*, certainty of finding an individual user is critical to the automatic location feature of NWN.

Tone signaling (*e.g.*, FSK, MFSK) ideally is suited for a simulcast network, since the information is represented by the presence or absence of an RF tone -- a characteristic that is maintained when varying phase/varying amplitude signals from different transmitters are summed. Classic modulation techniques are limited to use of a single tone per baud interval, however. Mtel specifically is experimenting with use of multitone variants of frequency shift keying known as permutation FSK ("PFSK"), multitone on/off keying ("MOOK"), as well as an innovative FM multitone modulation technique. These multitone variants are more complex to implement, but offer higher capacity while maintaining the relatively long baud interval required for simulcast operation.

Multitone techniques offer significant throughput advantages over standard FSK for simulcast systems. For example, standard FSK is limited to binary signaling -- switching between two tones designating either "1" or "0." FSK thus allows transmission of a single bit per baud interval, where the baud interval is defined as the rate at which the signal can be changed. More sophisticated schemes, known as orthogonal M-ary modulation, allow a system to transmit one of M different reference tones. It is generally agreed, however, that orthogonal M-ary systems with a large M are spectrally wasteful.

Multitone orthogonal M-ary FSK techniques transmit zero or more tones (as opposed to only one tone) selected from among M tones. MOOK, a multitone variant, uses a pilot tone to establish an "on" threshold for the baud interval, effectively

providing automatic gain control. Data are transmitted by keying the remaining tones. Mtel is exploring the use of 8 tone MOOK, which uses 9 tones to transmit 8 bits per baud interval (one tone is the "pilot"). Another variation, which may be appropriate for NWN, is an 8 tone modulation system where the system always transmits a total of 4 tones. This technique is known as "permutation modulation," or PFSK. Eight tone PFSK allows 70 symbols per baud, or 6.13 bits per baud interval.[6] Using a baud interval of 333 microseconds,[7] these schemes provide effective transmission rates between approximately 18,000 and 24,000 bps with spectral efficiency between 0.36 and 0.48 bits per Hertz.[8]

---

[6] From the 70 symbols available from the 4 out of 8 PFSK modulation, 64 are mapped into 6 bits of message information and the remaining 6 signals are used for data link control: *e.g.*, SYNC, ACK, NAK, frame and packet markers. Mapping the PFSK symbols into a binary stream provides compatibility with generic information sources (*e.g.*, computers, ASCII terminals) and the wealth of error control codes that have been developed for the binary channel.

[7] As shown in Appendix B, simulcast systems require a minimum signal element length, which empirically has been determined to be a baud equal to four times than the expected signal spread, from all significant transmitters, at the receiver. Currently, typical spreads in the paging service are on the order of 200 microseconds, implying a baud interval of 800 microseconds and baud rates of 1,250 baud. When binary FSK (one bit per baud) is used on this channel the current 1,200 bps limit becomes obvious. By using satellite-based synchronization and careful design, the spread can be limited to approximately 80 microseconds, which leads to a maximum baud rate of approximately 3,000 baud.

[8] For comparison purposes, standard FSK has a spectral efficiency of 0.05 bits/Hertz and ERMES has an efficiency of 0.25 bits/Hertz.

C. Adaptive Zoning of the Forward Channel Transmission Network Allows Mtel's Model NWN System to Increase Throughput to Satisfy Demand

Conceptually, when traffic is limited, a simple nationwide system (all messages transmitted to all locations) is an adequate solution for forward channel transmissions.[9] As the throughput of the system increases in aggregate, however, transmissions are subject to prohibitive time delays at best, and capacity exhaustion at worst. When saturation is imminent, however, the NWN central computers will divide the whole area into two or more zones according to traffic demands. Each transmitter will be informed with respect to which zone it belongs.[10]

The central computer will divide each time interval assigned to a terminal station type into nationwide and zonal portions (see Figure A3). The nationwide portion will be used for communications to stations with unknown locations or those located in overlapping areas between two zones. The majority of traffic will be in the zonal portion, however, so overall capacity can grow nearly linearly with the number of zones. This requires, however, that the user terminal location can be determined by

---

[9] Although Mtel's model NWN initially could be implemented as one "zone" -- *i.e.*, a solely nationwide system -- each NWN licensee utilizing zoned configurations should commit to establishing an initial network comprising at least two zones. This will require the licensee to gain experience with zoning and potentially avoid difficulties when zoning must be done.

[10] This scheme would allow Mtel's NWN system to reassign zone boundaries in real time to accommodate even temporary surges in traffic for particular zones. Dynamic zoning, however, entails complex signaling arrangements between base stations and the national control center, as well as a high level of computing power at the control center. Since zoning is transparent to the user terminals, however, even if fixed zoning must be employed initially, dynamic zoning could be implemented without requiring users to upgrade their individual terminals.

keeping a list of adjacent receivers (those which have successfully detected the station's latest transmission). Thus, Mtel plans to rely on its computers and telecommunications links between central computers and base stations in order to achieve higher spectral efficiency.

Mtel expects that the sizes of zones will decrease as traffic grows. A continuing traffic study of NWN data is critical to Mtel's zoning approach, since boundaries and the ratio of zone to nationwide time slots are set to ensure optimal efficiency. Optimal efficiency dictates that the number of zone slots be defined to achieve almost saturation loading for the zone with the highest demand.[11] When the number of slots dedicated to zonal traffic is set so that zone slots are generally filled, the nationwide slots also may be used to accommodate overload. Zone boundaries minimizing interzone interference and the number of users in the interzone areas also are critical.

One of the usual drawbacks of utilizing a zoned system to increase capacity is that the network must use capacity to track where users are located. Typically, this information is provided through an autonomous registration, a process requiring the user terminal either to identify a change in zone and send a registration message or to transmit periodic registration messages. An additional method available under Mtel's NWN system, however, is to use the packet acknowledgment, included to combat

---

[11] Mtel does not contemplate a hierarchy of zones at this time, since available market data do not indicate that the probability of finding a user terminal within a zone is sufficiently higher than the probability of finding the user terminal within a subzone to justify the additional infrastructure costs. Furthermore, a hierarchical structure would excessively complicate signal distribution and synchronization. Accordingly, time slots are national or zonal only.