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

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JUN 29 1992

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In the Matter Of:

Mobile Telecommunication Technologies Corporation	)	
	)	ET Docket No. 92-100
Request for a Pioneer's Preference Regarding its Petition for Rulemaking to Allocate Three 50 kHz Channels in the 930-931 MHz Band and to Establish Rules and Policies for a New Nationwide Wireless Network (NWN) Service	)	PP-37

ORIGINAL FILE

REPLY COMMENTS

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TECHNOLOGIES CORPORATION

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Dated: June 29, 1992

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Request for a Pioneer's Preference	)	PP-37
Regarding its Petition for Rulemaking	)	
to Allocate Three 50 kHz Channels in the	)	
930-931 MHz Band and to Establish Rules and	)	
Policies for a New Nationwide Wireless	)	
Network (NWN) Service	)	

REPLY COMMENTS

Mobile Telecommunication Technologies Corporation ("Mtel"), by its attorneys, herewith submits its reply comments in the above captioned proceeding. As detailed below, recently completed field tests have verified critical technical aspects of Mtel's Nationwide Wireless Network ("NWN") service.[1] An appended experimental report documents that NWN's unprecedented twenty fold increase in typical paging data speeds is feasible and practical with Mtel's innovative technology.[2] In addition, a recently completed Arthur D.

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[1] *Mobile Telecommunication Technologies Corporation Request for a Pioneer's Preference Regarding its Petition for Rulemaking to Allocate 150 kHz in the 930-931 MHz Band and to Establish Rules and Policies for a New Nationwide Wireless Network (NWN) Service*, ET Docket No. 92-100, PP-37 (filed November 21, 1991) ["*NWN Preference Request*"]. *See also Mobile Telecommunication Technologies Corporation Petition for Rulemaking to Allocate 150 kHz in the 930-931 MHz Band and to Establish Rules and Policies for a New Nationwide Wireless Network (NWN) Service*, ET Docket No. 92-100, RM-7978 (filed November 21, 1991) (proposing to allocate three 50 kHz channels for competitive NWN carriers) ["*NWN Petition*"]; *Mobile Telecommunication Technologies Corporation Technical Feasibility Demonstration on its Request for a Pioneer's Preference Regarding its Petition for Rulemaking to Allocate 150 kHz in the 930-931 MHz Band and to Establish Rules and Policies for a New Nationwide Wireless Network (NWN) Service*, ET Docket No. 92-100, PP-37 (filed June 1, 1992) ["*NWN Technical Feasibility Demonstration*"].

[2] Mobile Telecommunication Technologies Corporation, "Report on Field Tests of the Nationwide Wireless Network Service," (June 29, 1992) (attached as Exhibit a).

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Little study shows a potential market of 1.6 million NWN subscribers within five years.[3] This demand forecast is well matched with Mtel's proposal for three NWN assignments initially capable of serving 1.8 million to 2.4 million subscribers nationwide. With these submissions, the technical feasibility and business practicality of Mtel's proposed NWN service have been fully demonstrated.

I. SUMMARY

In response to Mtel's pioneer's preference request, the Commission received three basic objections.[4] First, Paging Network, Inc. ("PageNet") contends that Mtel's request is "premature" given purported doubts about the ability to deploy NWN "in a spectrally efficient manner on a timely basis."[5] Second, PageMart, Inc. ("PageMart") insists that NWN lacks sufficient capacity to meet the likely demand for advanced messaging services. Third, PageNet contends that any demand for NWN can be satisfied through other authorized services.

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[3] Arthur D. Little, Inc., "Quantitative Market Analysis of Demand for Nationwide Wireless Network Offerings" (June 25, 1992) (attached as Exhibit 2).

[4] *Comments of Paging Network, Inc.*, ET Docket No. 92-100, PP-35 *et al.* (filed June 19, 1992) ["*PageNet Comments*"]. PageMart's filing, tendered on June 16, 1992, is captioned as reply comments on both the rulemaking requests and the original pioneer's preference filings. In this regard, PageMart's continued violation of the Commission's rule requiring separate pleadings for pioneer's preference comments and rulemaking comments, *see* 47 C.F.R. § 1.402(c), makes it extremely difficult to identify the procedural context of PageMart's arguments and to reply to its arguments in the proper framework. PageMart has apparently also combined its comments on the *NWN Technical Feasibility Demonstration* in its June 16, 1992 comments. *Comments of PageMart, Inc.*, ET Docket No. 92-100, RM-7977 *et al.* (filed June 16, 1992) ["*PageNet Comments*"].

[5] *PageNet Comments* at 27.

Mtel's Field Tests Confirm its Ability to Deploy NWN in a Spectrally Efficient and Timely Manner. Mtel has just completed field tests of a working NWN system in Oxford, Mississippi. The test results show: (1) Mtel's Multi-Carrier Modulation ("MCM") techniques work in a simulcast environment; (2) simulcast speeds of 3,000 baud are feasible and practical; and, (3) a simulcast data rate as high as 24,000 bps is feasible and practical. In view of these positive results, Mtel is prepared to bring NWN to the marketplace within 12-18 months from receiving a license.

Mtel's Proposal Is Well Suited to Meet the Demand for Nationwide Wireless Network Services. A nationwide survey conducted by Arthur D. Little concludes that NWN would have a potential of 900,000 to 1,600,000 subscribers within five years. The study also shows that desired average message lengths conformed with Mtel's business planning assumptions. In such respects, Mtel's proposal for three competing NWN systems capable of initially serving 1.8 million to 2.4 million subscribers is well matched to the Arthur D. Little results.

Mtel's Innovative and Important New Service Warrants a Pioneer's Preference for Spectrum at 930-931 MHz. While PageNet blithely points Mtel in the direction of the 220 MHz band, that spectrum is channelized and licensed under rules incompatible with NWN system design and needs. Nor do any other existing services offer the nationwide features and functionality of NWN. With a modest 50 kHz assignment, the Commission now has the opportunity to approve a service which offers a great leap forward into the next generation of advanced messaging service for the public. Accordingly, the pioneer's preference request for NWN should be granted.

II. MTEL'S FIELD TESTS CONFIRM ITS ABILITY TO DEPLOY NWN IN A SPECTRALLY EFFICIENT AND TIMELY MANNER

PageNet states that Mtel "should not request spectrum for its NWN until it has completed technology development and can, without question, provide spectrum efficiencies."[6] Mtel agrees, as a general proposition, that feasibility -- including real world testing -- should be a highly important consideration in determining whether a pioneer's preference is warranted. The Commission, in fact, stated that "performance of an experiment generally will be extremely beneficial, since in most cases a substantially different technology or service will be proposed," and further noted that "the findings of [an] experiment will be one of the major components that we will use in determining whether a tentative preference is warranted."[7] This is precisely why Mtel expedited its experimental trials on the Multi-Carrier Modulation ("MCM") techniques. As discussed below and in the attached experimental report, Mtel's experimental efforts have fully validated the technical and commercial viability of MCM techniques in a real world test environment.

Mtel's immediate test goals were proving that MCM signals could be transmitted at baud rates up to 3 kbaud in a hostile simulcast environment and ensuring the detectability of high data rate MCM signals at such a baud rate. For these tests, Mtel also wished to ensure commercial viability, and consequently employed modified off-the-shelf equipment to the

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[6] *PageNet Comments* at 27. PageNet also states, wholly without support, that "Mtel itself is uncertain as to whether its system can be deployed in a spectrally efficient manner on a timely basis," citing a footnote in the *NWN Technical Feasibility Demonstration*. *Id.* What Mtel actually stated was that if, *for some unknown reason*, Mtel was unable to deploy an 8 tone MOOK system, NWN's ability to evolve provides a means for nonetheless deploying NWN immediately. *See NWN Technical Feasibility Demonstration* at 20 n.49.

[7] *Pioneer's Preference Recon.*, 7 FCC Rcd 1808, 1809 (1992). The Commission also stated that "an experiment [provides] further evidence that a party has expended significant resources and capital in the development of the new service or technology." *Pioneer's Preference Order*, 6 FCC Rcd 3488, 3493 (1991).

extent possible. Mtel's testing involved three phases: (1) equipment development and initial testing in Glenayre's laboratories in Quincy, IL; (2) laboratory tests with the modified equipment at the University of Mississippi's Center for Telecommunications ("UMCT") in Oxford, MS; and, (3) extensive field trials using these modified simulcast transmitters and a mobile laboratory in and around Oxford. A full report on Mtel's test efforts is attached as Exhibit 1.

Mtel combined the outputs of 8 Glenayre exciters, each coupled to its own 45 watt class C power amplifier, to form an 8 carrier signal in the laboratory, and alternatively to form two 4 four carrier signals for the field simulcast tests. In the field trials around Oxford, simulcast transmitter sites were selected to provide strong and weak simulcast overlap and non-overlap areas, as well as strong and weak multipath effects. Using this test set-up, eye diagrams were taken employing a high end digital oscilloscope and spectrum occupancy measurements were taken employing a scanning spectrum analyzer.

As shown by the data in Exhibit 1, several conclusions are immediately evident from Mtel's test program:

- The operation of Multicarrier Modulation ("MCM") meeting the proposed emissions mask has been demonstrated using a prototype field installation at Oxford, MS.
- Baud rates of 3 kbaud were demonstrated in the field trials, and baud rates in excess of 3 kbaud may be possible.
- Data rates of 24 kbps were demonstrated in the field trials, and higher data rates may be possible.

The field trials also showed that combined class C amplifiers are one practical means of achieving MCM techniques and that digital signal processing chips implementing a fast

fourier transform algorithm are a feasible means of receiving and decoding NWN signals in a portable MCM modem.

III. MTEL'S PROPOSAL IS WELL SUITED TO MEET THE DEMAND FOR NATIONWIDE WIRELESS NETWORK SERVICES

Mtel's proposed NWN system can support 600,000 to 800,000 subscribers initially and its capacity can be increased if needed. In order to ensure a competitive environment, Mtel has recommended the licensing of three NWN systems. Each system would be assigned a single 50 kHz channel for nationwide services.

With its background as the country's pioneer in nationwide paging services, Mtel was confident that its proposed service met an identifiable need for high speed, two-way messaging on a nationwide basis. NWN has been designed to support cost-effective delivery of such services. The system responds to the growing use of personal computers and pocket organizers by the business community and consumers.

In order to test its planning assumptions, Mtel retained Arthur D. Little, Inc. to conduct a market survey. During the past month, this well known and highly regarded consulting firm conducted a nationwide survey of adults in eight hundred households. The purpose of its undertaking was: (1) to assess the size of the market for the Nationwide Wireless Network-type service offerings over the next five years; (2) to gauge the service requirements that users have in terms of message length; and, (3) to determine the efficacy of nationwide, regional and local two-way advanced messaging service offerings.

Arthur D. Little's findings are set forth in the appended report entitled "Quantitative Market Analysis of Demand for Nationwide Wireless Network Offerings."[8] The study reaches several basic conclusions:

- ***First***, "[t]here is substantial demand for NWN-type services if provided in either the top sixty or the top one hundred markets. To the extent that complete coverage of all Metropolitan Statistical areas is possible, potential demand is even greater. . ."[9] Specifically, Arthur D. Little finds that the number of likely buyers over a five year period rises to between 923,000 subscribers for the top sixty metropolitan areas to 1,620,000 subscribers with coverage of all metropolitan areas.[10]

- ***Second***, the analysis of anticipated message length found that 59 percent of likely subscribers will send messages of two pages or less from NWN portables. "In addition, 41 percent reported that they will send messages [from NWN portables] of three to four pages and .5 percent indicated that they wish to send messages [from NWN portables] of five to ten pages. No one reported a requirement for messages longer than ten pages."[11] Similar results were also obtained for user's needs regarding receiving messages, with 70 percent expecting to receive messages of two pages, 14 percent expecting to receive messages of three to four pages, and 14.5 percent expecting to receive messages of five to ten pages.[12]

- ***Third***, from Mtel's perspective, a critical question surrounding NWN is the extent of user requirements for nationwide coverage. In such respects, Arthur D. Little found that "[t]he results indicate that a nationwide service encompassing three hundred markets is perceived to be substantially more suitable than is either local or regional coverage."[13] The study shows that 56 percent of those surveyed gave coverage of 300 metropolitan markets a "high suitability" rating.

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[8] Attached hereto as Exhibit 2.

[9] Exhibit 2 at 5.

[10] Exhibit 2 at 2.

[11] Exhibit 2 at 3.

[12] Exhibit 2 at 3.

[13] Exhibit 2 at 4.

In view of this well documented record, PageMart's claims that NWN fails to provide adequate capacity to meet demand have been fully refuted. The Arthur D. Little conclusions confirm Mtel's own internal estimates of likely demand for NWN. Moreover, they corroborate the well matched relationship between anticipated demand and NWN system capacity. In so doing, they confirm that NWN represents a sound business investment for Mtel as well as a sound spectrum investment for the country in meeting real public needs.[14]

IV. MTEL'S INNOVATIVE AND IMPORTANT NWN SERVICE WARRANTS A PIONEER'S PREFERENCE FOR SPECTRUM AT 930-931 MHz

A. NWN Functionality Cannot Be Replicated By Existing Wireless Systems

Notwithstanding the significant differences between NWN and conventional messaging systems, PageNet engages in a series of "apples and oranges" comparisons and concludes that Mtel's NWN system is not "technically superior to currently existing services."[15] PageNet asserts that the NWN enhancements could be offered in the 220-220 MHz band and also that the NWN enhancements are being offered on existing SMR systems. PageNet further disingenuously compares NWN's *simulcast* rate of 24,000 bps with *point-to-point*

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[14] PageMart, for its part, does not provide any demand studies. Instead, it simply asserts that the Commission's goal should be "[t]o support one to two million subscribers per MSA - not Mtel's realistically tiny capacity . . . ." *Reply Comments of PageMart* at 28. In offering these arguments concerning market size and system capacity, PageMart ignores the fact that fewer than twenty of the nation's MSAs even have a total population of two million. Moreover, PageMart's projections of 310 million to 620 million potential subscribers for the top 305 MSAs would exceed the entire U.S. population! The surrealistic nature of PageMart's assertions are perhaps best illustrated by the fact that the entire American paging industry only served an estimated 11.5 million subscribers in 1991.

[15] *PageNet Comments* at 27.

transmission rate in the ARDIS system of 19,200 bps and unfielded *point-to-point* rates of 2,400 bps in a 5 kHz channel.

PageNet's assertions are misleading and lack a rational basis. As Mtel has previously noted, NWN services could not be implemented on the 220 MHz frequencies because the 220-222 MHz band is channelized into 5 kHz channels and Mtel requires a 50 kHz channel. PageNet's remarks could be construed to mean that the simple ability to offer two-way data services on 220 MHz spectrum should preclude authorizing any new two-way data services. Such an argument, however, completely ignores the fact that the two-way data market, like the two-way voice market, is actually not a single indivisible entity, but rather composed of numerous submarkets. NWN is architecturally designed to respond to a particular demand -- the demand for low cost nationwide messaging -- that cannot demonstrably be served by systems that are created to operate on 220 MHz spectrum.

PageNet's further comparisons to real time data systems also ignore the fact that the market for two-way data is not a single market. Systems, like ARDIS and RAM, are designed as real time interactive services. These services establish a single transmitter to mobile link (*i.e.*, "point to point") for communications, unlike NWN, which is designed as a multitransmitter simulcast system. Furthermore, these services are characterized by comparatively large, more expensive mobile units with extensive power requirements and relatively higher service costs.

NWN, in contrast, is designed as a low cost consumer and business service that is not constrained to real time service goals, but rather provides functionality through ubiquity and flexibility. NWN, like the SkyTel™ service which is often used in conjunction with real time

cellular voice services, is designed as a complementary service to SMR and cellular systems. It will meet the needs of the many users who do not require, and do not wish to pay for, virtual circuit service for all data transactions.

When viewed in this light, any technological comparisons between NWN and point-to-point real time systems are even more inappropriate. Point-to-point transmission schemes using dedicated frequency or time channels are not constrained to the lower baud rates necessary in a low cost simulcast system. Increases in data rates therefore can be derived from a using higher baud rates instead of more complex signalling arrangements. Point-to-point systems, however, cannot provide nationwide services on a simulcast basis as proposed for NWN. Consequently, neither they nor any other existing service can effectively address the consumer market targeted for NWN services.

B. The Capabilities of the NWN System Surpass Existing Messaging Services and Offer Next Generation Functionality

Mtel's Nationwide Wireless Network ("NWN") system is a tremendous leap forward in messaging capability for the American public. NWN incorporates significant innovative technological advances to provide next generation capabilities that cannot be replicated by today's paging systems. As an enhanced messaging system, NWN also offers a unique combination of inexpensive terminals, lower cost service, and nationwide ubiquity that responds to entirely different needs than real-time two-way data systems currently offered, for example, on SMR and cellular radio systems. As discussed below, NWN has been carefully crafted to respond to a public demand for two-way functionality in a low cost nationwide messaging service.

Today's paging systems offer important, economical, and needed capabilities for the American public. While offering some messaging capability, today's systems are one-way, place constraints on message size, lack confirmation of delivery, and are typically limited to simulcasting at 1,200 bps.[16] Accordingly, as requirements increase in the future, these systems will not continue to support the needs of the vast growing base of highly mobile portable computer users. The advanced messaging functionalities demanded by these users simply cannot be offered through the technology employed on existing systems. Mtel consequently developed a next generation service -- NWN -- to meet these public needs.

In order to implement NWN on a spectrum efficient and low cost basis, Mtel has investigated and proven out a number of innovative technological advances. In particular, the NWN system combines the following technological breakthroughs to substantially increase the scope of messaging capabilities:

- ***High Speed Simulcasting.*** NWN will support extensive high speed simulcast messaging at up to 24,000 bps to facilitate a high capacity nationwide service. This data rate is an order of magnitude faster than the current implemented state-of-the-art -- SkyTel™'s 2,400 bps data rate also pioneered by Mtel. Developing a data rate of 24,000 bps for a simulcast system required Mtel to employ high dimensionality multicarrier modulation techniques for the first time in a messaging environment.

- ***Advanced Dynamic Frequency Management.*** NWN employs an Advanced Dynamic Frequency Management ("ADFM") scheme to achieve significant frequency re-use and to optimize use of spectrum by utilizing a high degree of centralized processing power in the network. ADFM combines a number of highly innovative frequency conservation measures that will allow NWN to: (1) utilize a nationwide and zonal format for forward channel frequency re-

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[16] Most existing simulcast paging systems operate at rates of 1200 bits per second or less. During 1991 Mtel pioneered the development of 2400 bps technology for the industry. Mtel has deployed this technology for its SkyTel™ network. NWN will also operate at a faster data rate than the forthcoming European Radio Messaging System ("ERMES"), which will deliver data at 6,250 bps. Mtel is participating in the implementation of ERMES through its United Kingdom subsidiary.

use, (2) employ base receivers on an individual basis to permit reverse channel frequency re-use, (3) dynamically control access to system resources, (4) minimize inefficiencies caused by contention inherent in portable generated requests to transmit, and (5) tailor location tracking schemes for optimal use of resources.

Individually and in combination, these innovations shatter the limits currently imposed by existing paging systems and allow NWN to offer cost-effective and spectrum efficient enhanced messaging capabilities.

Mtel's NWN system offers unsurpassed capabilities and functionalities in a messaging system. NWN's features, required to support the data transfer needs of the American public, include:

- ***Full Two-Way Messaging Functionality.*** NWN will support multiple levels of reverse channel service depending upon the specific requirements of the end user -- automatic acknowledgement from portables that a message has been received to support "return receipt requested" applications; user-interactive simple preformatted acknowledgements to confirm messages have been received by the end user; and, full two-way transfer capability for short and extended length digital data.

- ***Nationwide Simulcast Coverage.*** NWN offers transparent nationwide coverage familiar to today's users of wide area and nationwide paging systems, with the benefits of simulcast. Simulcasting enhances coverage continuity and building penetration, as well as allowing low cost network growth.

- ***Low Cost, High Efficiency Portables.*** Mtel has estimated that NWN portables, which can be stand alone units or plug-in cards compatible with a wide range of portable and laptop computers as well as personal organizers, will have wholesale prices under $300. These units will be simple, compact, and, due to the efficiency of the ADFM protocols, will have extended battery life critical to satisfying the needs of highly mobile customers.

- ***Application Independence.*** NWN offers an application independent digital data transmission service that can be customized for each user's requirements. Virtually any kind of store-and-forward compatible application can be customized for use with NWN by simply creating software for portable computers and the host computer to take advantage of NWN's open architecture.

- ***Adaptable Functionality.*** NWN supports variable levels of error detection and correction capability, as well as encryption, prioritization, and many billing options depending upon each end user's requirements.

- ***Support for Industry Standards and Customized Needs.*** Interfaces supporting numerous industry standards are planned to allow the broadest compatibility between NWN and wireline messaging systems. Specialized arrangements will also be available to support specific needs for customers.

This remarkable array of features marks NWN as a unique response to the data transmission needs of mobile users. NWN offers unparalleled flexibility in a blend of form and function that is truly next generation messaging.

VI. CONCLUSION

As documented in the record before the Commission, Mtel has developed an innovative and publicly beneficial new service. Its NWN system offers enormous new advantages and capabilities to meet the public's advanced messaging needs. The reports appended to these reply comments confirm the technical feasibility of the NWN system and Mtel's well conceived plan for meeting real marketplace demands. In such circumstances, Mtel has met all of the Commission's strict criteria and the grant of a Pioneer's Preference is clearly warranted.

Respectfully submitted,

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Dated: June 29, 1992

CERTIFICATE OF SERVICE

I, Eric DeSilva, hereby affirm that on this 29th day of June, 1992, I have caused copies of the foregoing "Reply Comments" to be delivered, First Class Mail, postage pre-paid, to the following, except where service by hand is indicated:

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TAB 1

Report On Field Tests of the Nationwide Wireless Network Service

Mobile Telecommunication Technologies Corporation

June 29, 1992

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EXECUTIVE SUMMARY

Pursuant to its experimental license, Mtel has conducted field tests of its NWN system.[1] The purpose of the tests was to evaluate in an over-the-air environment the feasibility of Multi-Carrier Modulation ("MCM").[2] As detailed below, the results of the experiments were all positive.

A prototype NWN system was assembled in Oxford, Mississippi, at the University of Mississippi Center for Telecommunications ("UMCT") and testing occurred in and around the Oxford area. With the facilities and assistance of Glenayre Electronics, Mtel was able to construct transmitter and control equipment capable of transmitting multiple carriers over a 50 kHz channel. Eight 45 watt transmitters were combined in groups of four to produce a 3 kbaud simulcast system and in groups of eight to produce a 24 kbps transmitter.

The field experiments verify that:

- The operation of Multicarrier Modulation ("MCM") has been demonstrated using a prototype field installation at Oxford, MS.
- Speeds of at least 3 kbaud were feasible in the field prototype.
- Speeds in excess of 3 kbaud may be possible.
- Data rates of at least 24 kbps are achievable, and higher data rates may be possible.
- MCM transmitters meeting the proposed emissions mask can be constructed.

With these results, Mtel has demonstrated that MCM is a practical and viable method of achieving its goals for NWN.

Mtel's ongoing test program will further refine the techniques demonstrated by these tests. Additional areas of testing will include the effects of multiple simulcast transmitters, other means of obtaining highly linear amplification, and fabricating various types of prototype receivers. Mtel's plans in this regard were set forth in its June 1, 1992, *NWN Technical Feasibility Demonstration*.

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[1] Mobile Telecommunication Technologies Corporation Experimental Radio Authorization KK2XIO, File No. 2353-EX-PL-91 (April 6, 1992).

[2] In earlier pleadings, Mtel referred to Multi-Carrier Modulation or MCM as "enhanced multitone modulation." Because MCM is more descriptive, this nomenclature has been used throughout this report.

1.0 INTRODUCTION

This report sets forth the results of Mtel's field tests of its NWN system, authorized by the FCC in an experimental license granted on April 6, 1992.[3] The license was issued for three cities: Oxford, MS; Dallas, TX; and Washington, DC. As described in the request for experimental license and in the subsequent *NWN Technical Feasibility Demonstration* of June 1, 1992, phase one of the experimental procedure was to take place in Oxford, MS, in conjunction with the UMCT.

1.1 Objectives And Procedures

Mtel decided to revise its planned test schedules and first evaluate its Multi-Carrier Modulation ("MCM") techniques in order to conclusively address comments made by other parties in response to Mtel's June 1, 1992, *NWN Technical Feasibility Demonstration.*[4] To that end, Mtel proceeded with an experiment to construct and test transmitters capable of transmitting MCM signals. With the assistance of Glenayre Electronics, Mtel devised and developed transmitters and control equipment capable of accomplishing this goal.

These tests were performed in three distinct stages. The first stage took place at the laboratory of Glenayre Electronics, in Quincy, IL. Here the transmitters were fabricated, the

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[3] Mobile Telecommunication Technologies Corporation Experimental Radio Authorization KK2XIO, File No. 2353-EX-PL-91 (April 6, 1992).

[4] Mtel's original test schedule involved research into propagation and timing of simulcast systems and extensive low level testing. Although the instant tests are the single most valuable confirmation of the overall operation of NWN, the original test schedule was calculated to develop other necessary insights into developing an optimal NWN simulcast system. Accordingly, with the conclusion of this test, Mtel will return to its program of experimentation as described in the June 1, 1992, *NWN Technical Feasibility Demonstration.*

receiver modified, and the data generation and synchronization arrangements constructed (see Figs. 1-7). The Glenayre laboratories also were the location where the most extensive spectrum occupancy tests were performed and the measurement techniques were perfected. Following these tests the equipment was staged, packed for shipment, and sent to Oxford, MS. At Oxford a series of laboratory tests confirmed the safe transit of the equipment and its continued performance at the high levels observed in Quincy (see Figs. 8-9). The third stage of the testing involved the mobile laboratory van in the Oxford area to determine the performance of MCM in a real world simulcast environment (see Figs 10-11).

The transmitter sites selected for the third stage of the experiments were chosen for specific characteristics, including:

- The ability to have weak and strong simulcast overlaps and weak and strong non-overlap areas.
- The ability to have areas with both large and small amounts of multipath.

The selected sites included a tower approximately 7 miles to the north of UMCT with the antenna mounted 150 feet above ground level ("AGL") (see Figs. 12-15) and the engineering building at the University of Mississippi with an antenna height of 68 feet AGL (see Figs. 16-18). Both sites used omnidirectional 6 dB gain antennas. The antenna heights were chosen to assure low angle of attack of the direct ray in order to allow for high ground attenuation and sufficient multipath to prove out the system concepts.

Mtel's primary goal was to prove that MCM could be accomplished on a commercially viable transmitter. This required verification that MCM could work at high baud and bit rates in a hostile simulcast environment. To this end Mtel has been successful.

1.2 Scope

The remainder of this report consists of the following sections:

- Test Arrangements
- Test Procedures
- Current Results
- Conclusions
- Future Efforts

In addition, Appendices containing supporting documentation, including charts, graphs, spectrum analyses, are attached along with photographs of the various stages of the experiment.

2.0 TEST ARRANGEMENTS

The approach taken in all of these tests was to evaluate the practicality of simulcasting Multi-Carrier Modulation ("MCM") signals. Toward that end, off the shelf instruments and modified components were used. In particular, the transmitters were assembled using standard paging transmitters and the receiver was implemented by using the Fast Fourier Transform ("FFT") capabilities of a digital oscilloscope. This approach allowed expeditious confirmation of the spectral compliance of the MCM signals and the feasibility of reliably detecting these signals.

2.1 Data Generator

A pseudo-random data stream, generated by a feedback shift register, was the data source for these experiments. The sequence length was 63. Synchronization of the data stream at the two transmitters used for simulcast testing was provided by an auxiliary channel

of the control link equipment. For some tests, fixed bit patterns, rather than random patterns, were utilized.

2.2 Transmitter

The test transmitters were assembled by using combiner summation of individual isolator protected RF power amplifiers for each of the carriers. A total of eight Glenayre 45 watt class C power amplifiers, assembled as two banks of four amplifiers, were used. Each amplifier, operating at a nominal frequency of 930.9 MHz, fed into a circulator that protected that amplifier from impedance mismatches or the signals from other amplifiers. Each bank of four amplifiers was summed in a simple star combiner and, for those experiments that required 8 carriers, the two banks were summed with a simple parallel arrangement. No attempt was made to impedance match the outputs of the circulators or parallelled arrangements. Instead, the circulators were relied upon to eliminate intermodulation problems and the losses (approximately 10 dB) were accepted as reasonable in this phase of experimentation. Details of the design construction and testing of the transmitters are contained in Attachment A.

Previous studies performed for Mtel[5] showed that a high degree of linearity would be required from a single amplifier if the intermodulation products were to meet the requirements of the proposed spectral occupancy mask.[6] In order to avoid the cost and time required to fabricate such a linear amplifier, this multiple amplifier approach was taken.

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[5] *NWN Technical Feasibility Demonstration* Exhibit A.

[6] *See* Proposed Rule 22.1206 (*NWN Petition*, Appendix C at C12).

Future studies will continue to investigate the best means for providing the power amplification in the fielded NWN but this experiment showed that at least one approach (one power amplifier per carrier) is capable of providing the spectral occupancy results needed.

2.3 Transmitter-Receiver Link

All of the tests used high power transmitters and sensitive receivers (no "low-level" tests were performed). Since the modulation technique involved the direct keying of the final RF amplifiers, it was not possible to perform exciter/demodulator or other low level tests. This increased the reality and credibility of the laboratory testing. However, it also increased the complexity of the tests because the laboratory studies needed high-power attenuators to reduce the signal levels to a range compatible with the receiver front-ends and field work could not begin until the transmitters were constructed and tested.

2.3.1 Laboratory Links

A 30 dB power attenuator, followed by a low power step attenuator provided the transmitter-to-receiver link in the laboratory. Leakage paths that bypassed the attenuators, including direct exciter to receiver paths, were a problem. However, these problems were overcome and successful laboratory measurements were performed. These results, reported in Appendices A and B, showed that (1) an MCM transmitter that conformed to the spectrum occupancy mask proposed in Mtel's November filing could be constructed, and (2) a Fast Fourier Transform of the signal could successfully recover the modulated data.