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Omnipoint Experimental License Report
August 1993

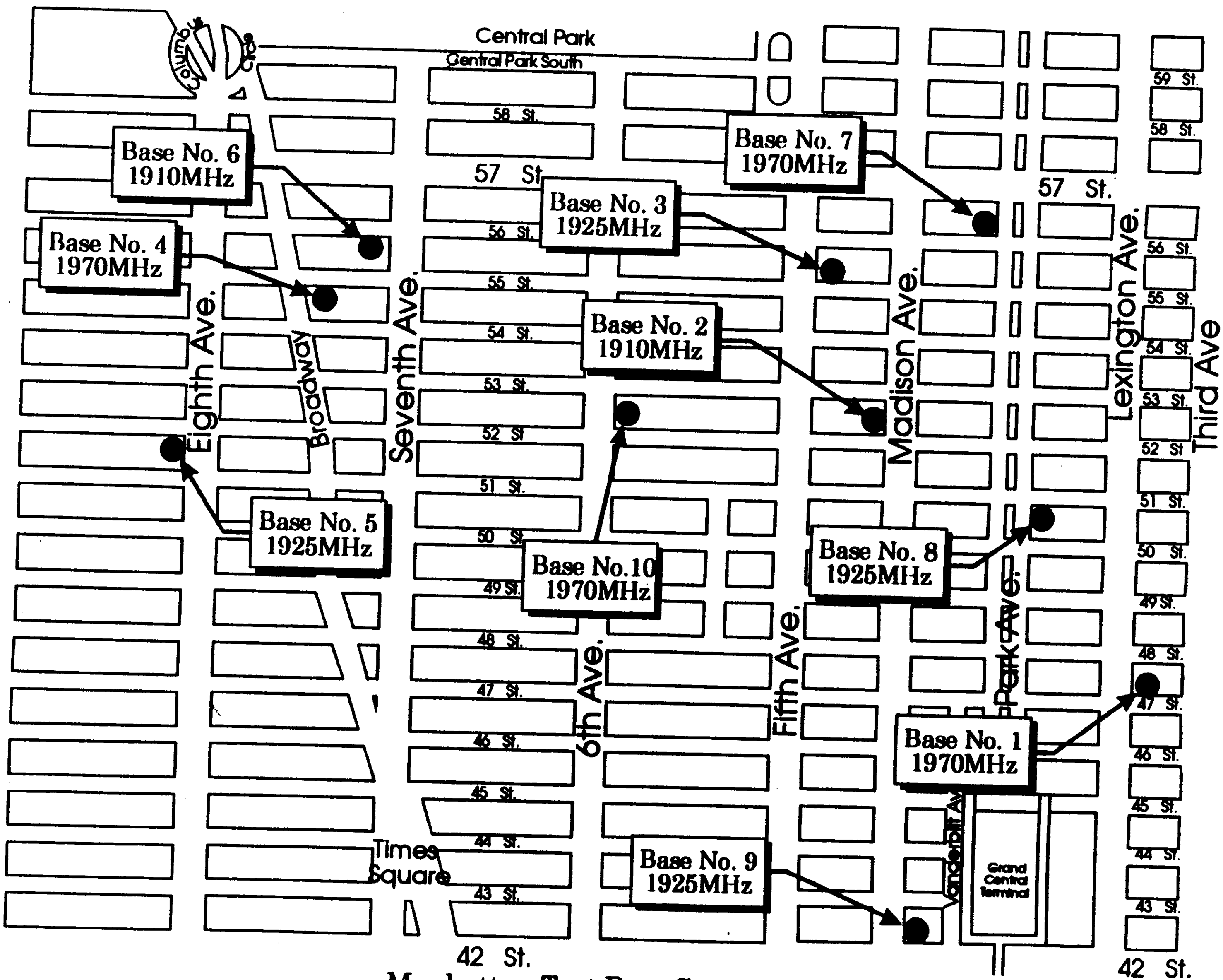
1 Overview

In addition to the numerous tests which Omnipoint has conducted of its 1.9Ghz PCS system with other companies over the past two years, Omnipoint has undertaken solely at its expense one of the largest and most comprehensive set of technical trials of any PCS system. We have conducted both microcell (2000 feet and under) multicell tests as well as macrocell (greater than one mile radii) multicell tests, all with full mobile handoff, and using at most an N=3 reuse pattern. In conjunction with LCC, one of the premier RF consulting and cell site planning firms in the country, Omnipoint has performed extensive testing of its system in highly diverse RF environments. This Progress Report documents the recent large scale tests in New York City and Colorado Springs.

In the New York City area Omnipoint has spent millions of dollars to conduct a trial of its system using up to 12 cell sites to demonstrate the functionality and economics of its network architecture in a true microcellular, N=3 reuse, dense urban environment. Omnipoint spent several months modeling the RF environment of Manhattan, designed and built a micro network, performed extensive field studies of the propagation and multipath characteristics of this unique RF environment, and performed extensive drive and walk tests of its 1.9Ghz PCS network and handsets.

In parallel, to demonstrate the Omnipoint system in less of an "urban canyon" RF environment, Omnipoint constructed 3-4 cell configurations in Colorado Springs, CO ("COS") which includes 3 - 6 miles of coverage along the major interstate highway, plus complete coverage of a single neighborhood quadrant within the total area covered by the configuration of cell sites. This quadrant is slightly larger than a square mile in area and includes a residential neighborhood, several office complexes, multiple small businesses, and strip malls.

Note that Colorado Springs is the 52nd largest city and the 84th largest MSA in the U.S. This means that roughly 90% of the MSAs/RSAs are smaller in population. Thus, real world cell site testing and economic planning of a PCS network in COS is highly meaningful if PCS is ever to offer the promise of near universal service. Several PCS technologies are too expensive in just their initial base station and cell site costs to justify constructing a network to be the fourth, let alone fifth, sixth, etc. operator in a city such as Colorado Springs. Omnipoint is designing its system to lower the infrastructure costs to the point where PCS can be provided to virtually any community.



Manhattan Test Base Station Locations
Configuration No. 1

Both the New York and COS tests were conducted with at most an N=3 frequency reuse pattern. Frequencies were selected after careful examination of the OFS frequencies in use within the theoretical OFS exclusion zones for each location. For the Colorado Springs tests, we selected two of the 10Mhz channels such that they employed the same frequency division duplexed (FDD) 80Mhz separation as the existing OFS channelization scheme. Although Omnipoint's system is being tested in a time division duplexed (TDD) configuration, Omnipoint will use the proposed FDD PCS spacing of 80Mhz to improve the PCS reuse pattern and mitigate adjacent channel issues. Thus, testing with the 80Mhz FDD channelization was a key element of the Colorado tests.

BACKGROUND TO THE NYC AND COLORADO TECHNICAL TRIALS

Perhaps one of the most important and yet most overlooked aspects of PCS at 1850-1990Mhz will be the problem of acquiring cell sites. This problem is compounded by the fact that there will inherently be many more cells required to offer full functionality 1.9Ghz PCS as compared to 800Mhz PCS. Cells at 1.9Ghz will be smaller than 800Mhz cells for several reasons: 1) Average received signal strength (RSS) levels are 10-15db lower (not just the 6.8db which theory would predict); 2) Fast fading is much more frequent; 3) Deep fades are much more probable; 4) The rate of fading is more than two times faster; 5) Shadowing is much greater (average signal strength can easily drop 25-30db around a corner or behind objects); and 6) Handsets will be limited to lower power levels (i.e., roughly 300mW) which will cause all PCS systems to be uplink limited. (See Figure 3-5 for comparison of 800MHz and 1.9GHz.)

The fact that many more cell sites will be required per operator coupled with the increase in the number of operators will virtually mandate that zoning boards will prohibit the general construction of classical cellular type towers with 100'-200' foot or higher antennae heights. No community is likely to allow its skyline to resemble that of an oil field with hundreds of derricks. This means that cells will have to be mounted on existing structures and be highly inconspicuous. In suburban residential neighborhoods this may mean using existing telephone and cable TV poles and cabling. However, mounting antennas at 25 feet will again dramatically reduce the cell coverage, as shown in Figure 3-6, thereby yet again increasing the number of required cell sites.

The requirement for many more cells dictates that the cost per cell and the cost per cell site installation must be dramatically reduced if new 1.9Ghz PCS networks are to be economically competitive to existing 800Mhz wireless networks and offer consumers reduced prices.

Omnipoint spent much of its infrastructure design and development efforts focused on reducing the cost and size of its base stations and reducing the cost of internetworking them. Further, we have designed the architecture to distribute the processing as much as possible back to the concentration points -- e.g., the Base Station Controllers and the master switching network (which may be a PCS Telephone Switching Office (PTSO), or the standard Public Switched Telephone Network (PSTN)).

Omnipoint has designed six classes of base stations. The smallest is currently 3.5" x 8.5" x 10" and can be mounted virtually anywhere including in the ceilings of most offices (for coupling to outdoor or indoor antennae) or even hanging from standard telephone or CATV lines. A future version one half that size is being developed for even easier mounting. We believe that the availability of this small size a base station is necessary to increase the PCS operators flexibility in choosing cell sites, and particularly critical for "filling in" coverage holes due to variations in terrain and building shadowing. Progress reports regarding Omnipoint's tests with several Cable TV operators have also demonstrated the benefits of such small base stations, especially for mounting from the "strand" itself. Typical cell site equipment for other technologies is measured in each dimension in terms of multiple feet even for so called microcells, and will require floor space or roof space with all the concomitant needs for housing and access.

As will be seen in more detail below, cells in Manhattan do not propagate as concentric circles. Rather, depending upon the exact antennae mounting, standard cells propagate in patterns which primarily resemble lines and crosses. As an example, Figure 1-4 shows the -85dbm mean RSS pattern for one particular site. Even more important, the fast fading characteristic of 1.9Ghz in Manhattan are such that as many as 1% of the fades will drop the RSS <u>below -110db as a close as one block away around a corner or on the opposite side of the building from the cell site</u> (See Figures 1-5 vs. 1-6).

This phenomena lead Omnipoint to design, install, and test the diagonal, cross grid, cell site pattern in Manhattan detailed below.

The Omnipoint handsets used for the Manhattan and Colorado Springs tests have receiver sensitivities of a maximum of -93dbm to -95dbm at a zero Frame Error Rate. In deep fading or high shadowing environments, RSS below -95dbm causes packet muting. Above a Frame Error Rate of 10-2 this muting becomes audible as interruptions to the voice quality (almost universally, but mistakenly, referred to as "pops and clicks").

Based on actual experimental data, the wideband nature of Omnipoint's signal appears to provide 5-8db of resistance to frequency selective fades compared to narrowband signals as shown in Figures 3-1 and 3-2. Fast fading data collected from several environments suggests that 17-18db of fade margin is required to maintain a Frame Error Rate (FER) of less than 2%. (See Figures 1-19 to 1-24.) Thus Omnipoint targets its cell site configurations to provide average RSS of -85dbm within the coverage area of each cell as well as the overlap zones between cells. Except in multipath or shadowing environments which exceed the above fading margins, this target RSS generally provides excellent voice quality. This is particularly evidenced in the Colorado Springs tests.

However, Omnipoint is not satisfied with the performance of the current implementation of the system at these target RSS and fade margins given the high degree of multipath and shadowing actually experienced in many real world environments at 1.9Ghz. Work has been ongoing to increase the receiver sensitivity of the link to up to -104dbm before fade margin. Further, all of the tests to date of Omnipoint's system which have been reported on (including those below) do <u>not</u> use combining diversity. This has been implemented in two lab prototypes and has been shown to significantly improve performance as expected. These will be used in future tests.

2 System Description

Handoff in the Omnipoint system is mobile-centric (i.e., handoff to a new Base Station is directed by the mobile) in contrast to all existing cellular systems which are net-centric (i.e., the network makes the handoff choices and decisions even if using RSSI and FER information gathered by the handset for helping determine the handoff, such as in MAHO systems). This unique feature of Omnipoint's architecture allows handoffs from one base station to another on any of the frequencies throughout the 140Mhz of the 1850-1990Mhz band to be performed in tens of milliseconds even when the link to the original base is lost before signaling information can be completed. The major benefit of this design feature is to allow high speed handoff in very small cells. This technique was the subject of much of the testing in Manhattan and Colorado Springs.

In general, in the test configurations used to date, the Omnipoint handsets will attempt a handoff at mean RSSs of between -85dbm and -90dbm, depending on the FER due to the rate and duration of fading below -95dbm. Based on the qualitative Figure of Merit (FOM) scores shown for the two representative Manhattan cell site coverage plots shown, it can be seen that this generation of handsets can hold the link to areas where the 1% CDF fades average to -105dbm. See Figures 1-8 to 1-11.

Drive tests in both Manhattan and Colorado Springs have demonstrated excellent voice quality over 99% of the routes covered by using the above RSS and fade margin targets for cell site choices. <u>One has to recall that Omnipoint's systems are transmitting several hundred thousand bits per second with only 100mWatts and operating in a fully mobile Rayliegh fading environment without the use of equalizers or combining diversity.</u> However, because the combining diversity receivers were not used for these tests while fades up to 30db and even 40db were occasionally noted (especially in Manhattan in NLOS conditions), so called "pops and clicks" could occur in locations even where mean RSS was recorded at -85dbm. Omnipoint expects the next iteration of testing with the upgraded equipment to show that this will have largely been eliminated.

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10 December 1992

Ms. Donna R. Searcy
Secretary of the FCC
Room 222
1919 M Street N.W.
Washington, D.C. 20554

Re: Experimental License Reports -
No. KF2XEH, File No. 1629-EX-PL-90
No. KK2XCV, File No. 2174-EX-PL-91

Dear Ms. Searcy,

Over the past six months Omnipoint has performed extensive testing in a variety of environments and with many diverse modulation techniques at varying bandwidths. Much of our research has been conducted in conjunction with our customers, and the results of those tests are either just now becoming available or will become available over the next eight to ten weeks. Additionally, Omnipoint has planned several highly involved tests during the next several weeks. The completed test efforts have yielded much invaluable data on propagation effects of various types of signals in multiple frequency bands, and tests currently in progress and planned for December and January should augment the data already compiled.

In order to complete the testing planned, and corroborate future and in-progress test results with preliminary results already compiled, Omnipoint respectfully submits this abbreviated report and will submit more complete and extensive summary of tests and hardware development results in January or February of 1993.

Among the contents to be submitted in the next report will be additional information on some of Omnipoint's preliminary test and development results across the bands that this current report covers.

Highlights

Since the last experimental report was submitted, Omnipoint has made several advances in its pioneering developments. These include:

- Multicell hand-off capability - Omnipoint has successfully performed direct sequence spread spectrum over-the-air multicell hand-off.

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• Two way calling - Omnipoint has added the feature of two way calling whereby a call not only may be initiated from the mobile handset, but also received from the network. Base station architecture design allows for several network interfaces depending upon the application through a base station design that supports multiple registered users.

• ISDN interface - Omnipoint has demonstrated a base station utilizing an ISDN interface to the PSTN in a laboratory environment, and both two-way calling and initial hand-off capability have been successfully accomplished. Further development and testing of this interface and others is to follow in the coming weeks and months.

• Outdoor extended range functionality - The current generation of pocket telephone has been tested in line-of-site operation to its current digital limit of 4200 feet. Depending on antenna configuration, this could allow for cell spacing of 1.6 miles in less dense areas. Figure 1 shows the immediate vicinity of the Omnipoint facility in Colorado Springs with a flat open field to the north, and a hilly, residential area to the east. Handsets were only tested in one direction in order to replicate tests of earlier generation equipment.

In Figure 1 the shaded portion represents the coverage area of the current generation 1.85 - 1.99GHz pocket phone configured with 90mW peak output power in the base station and 40mW in the handset. For these shaded portions, a call may be placed, received, and maintained within the coverage area. These plots represent initial tests, with more extensive testing to be performed in the coming weeks.

• Indoor range functionality - Significant performance properties indoors have also been shown in preliminary tests. Omnipoint has tested the same generation 1.9GHz telephone equipment detailed above in a variety of indoor environments, and shown that well designed direct sequence spread spectrum systems show much promise to be able to provide economic coverage for such applications as wireless PBX, Centrex, and Key systems.

In testing this system, sites have been sought out which demonstrate *extremely* difficult multipath environments in order to test the effect delay spread can have on any RF system, but on wideband systems in particular. A Conference/Hotel facility in New Jersey has proven to be such a site. This facility has 7 foot high ceilings, 18 inch thick brick walls, tiled floors, and metalized floor to ceiling

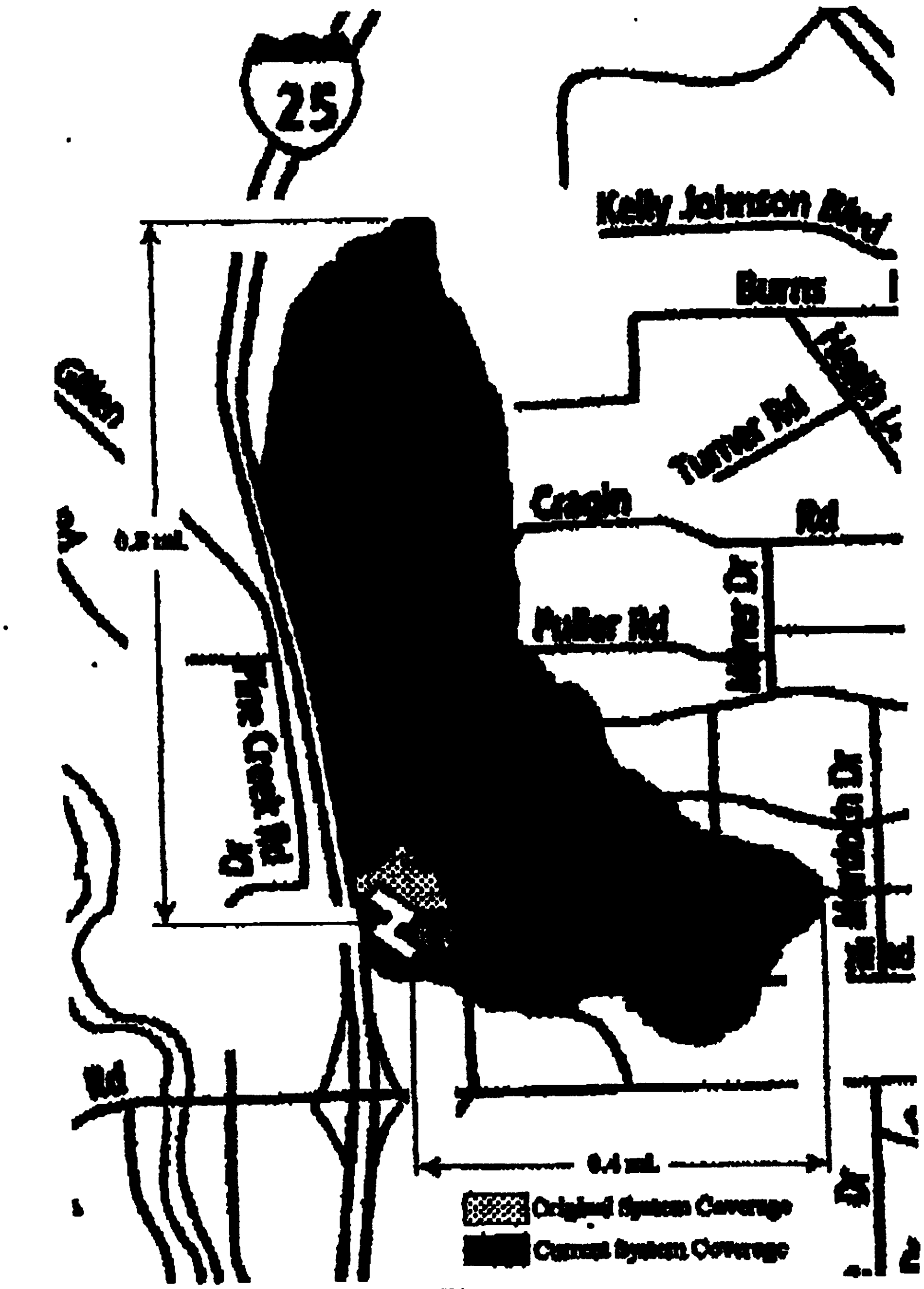

Figure 1
Coverage Plot of 1850MHz Pocket Phone
Omnipoint Facility, Colorado Springs, Colorado

windows, thus providing a highly reflective, extremely difficult multipath and attenuation environment. Omnipoint has performed functional tests in this facility, with preliminary resultant coverage plots detailed in Figures 2 and 3. The Omnipoint system had superior coverage when

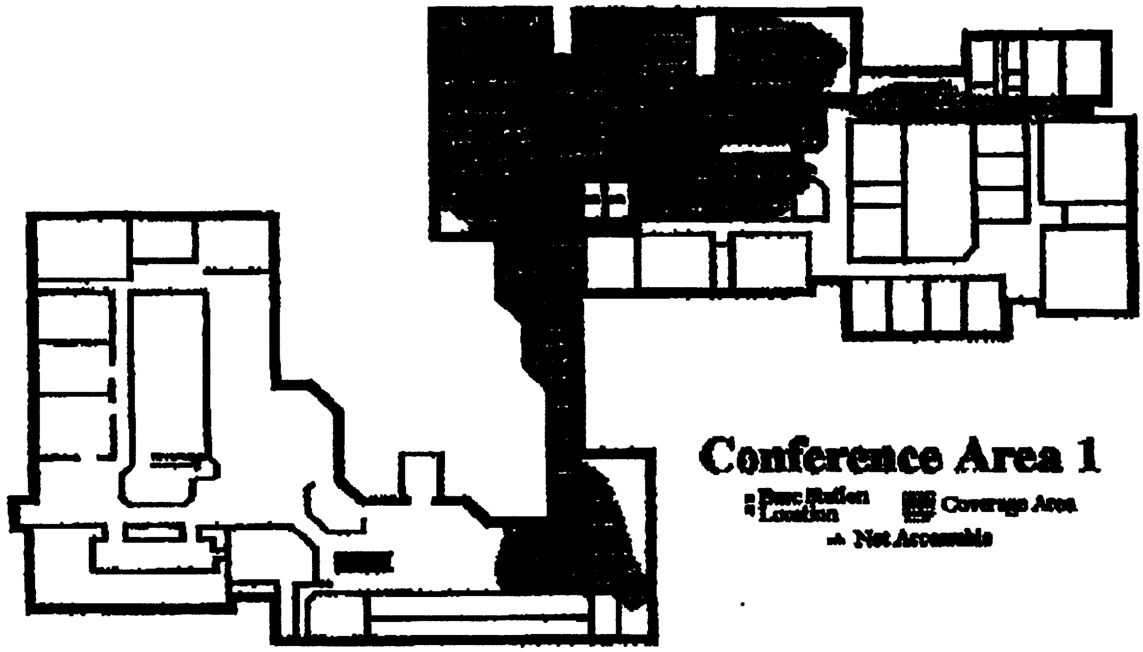

Figure 2
Coverage Plot of 1850MHz Pocket Phone, Location 1
Conference/Hotel Facility, New Jersey

compared to other commercially available wireless handheld systems. The Omnipoint system was also compared in this environment to a prototype non-spread spectrum system that offered a slightly larger coverage plot (operating roughly 15 feet further than did the Omnipoint system). However, this other system was not a handheld device, but rather a shoulder toted unit roughly 60 times the size of the Omnipoint device and employed antenna diversity in the "handset" as well as the base station.

But perhaps most interestingly, non-handheld devices do not suffer from the "head effect" at 1.9GHz, which is described below.

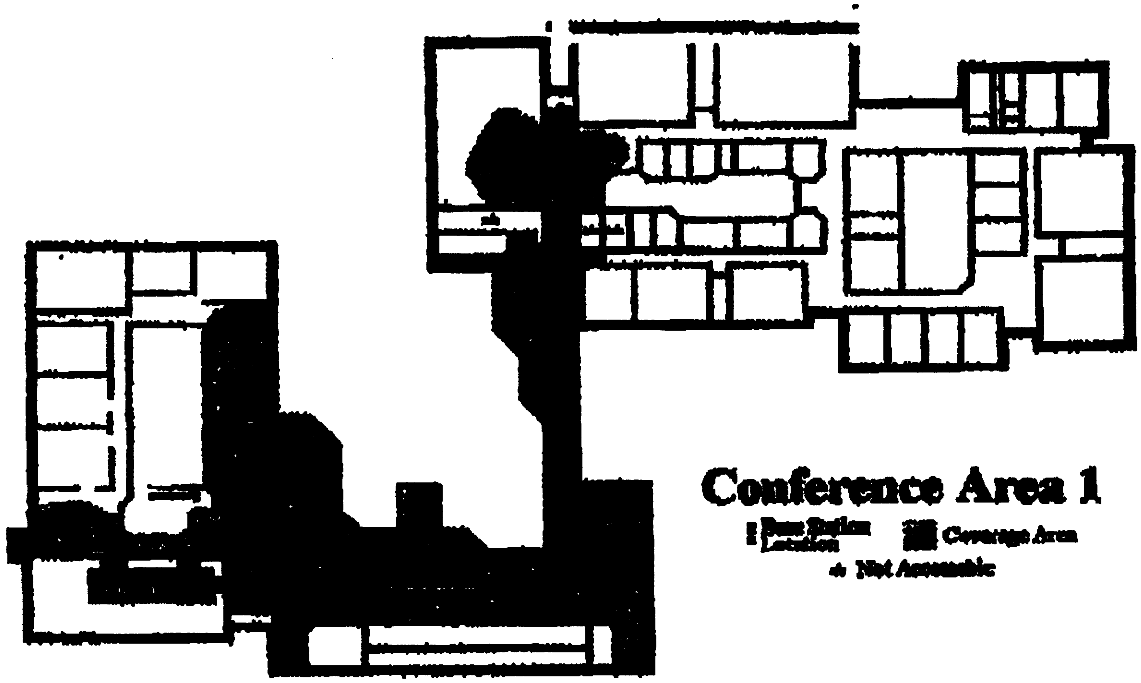

Figure 3
Coverage Plot of 1850MHz Pocket Phone, Location 2
Conference/Hotel Facility, New Jersey

As part of our study, tests have been performed to observe the affect of the human head on low power emitted signals in the 1.85GHz - 1.99GHz band, and Figure 4 is a good representative sample of the attenuation effects of a human head on such a signal. Initial tests show that signal attenuation of this nature is common whether the head is located between two link antennas, or behind one of them. For example, when a wireless telephone handset is placed next to the head (as in normal use), typical signal degradation is 10 to 12 dB even when not blocked. These initial test results yield several ramifications but graphically illustrate why tests of handheld devices can produce significantly different results than tests of "shoe box" or van size prototype systems which are not handicapped by the constraints of real world conditions. It is assumed this phenomenon is due to radiator near field characteristics, and further studies are planned, with progress and results to be reported.

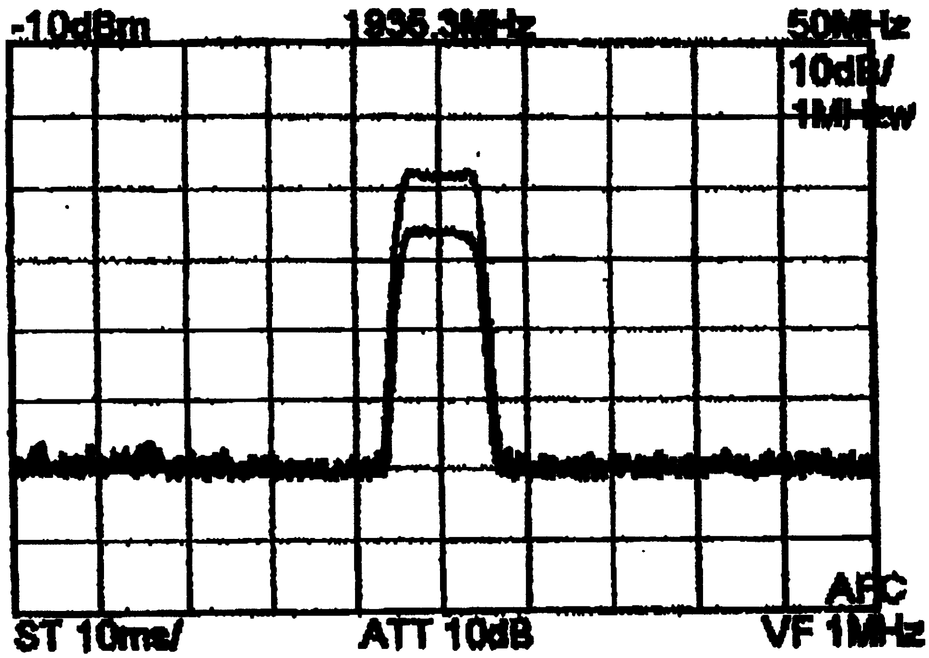

Figure 4
Human Head Effect

As Omnipoint and other experimenters have documented earlier, using mean power level techniques to determine signal strengths in indoor environments can be highly misleading as actual signal strengths can vary dramatically around the mean, and reveal little regarding rate of fading due to multipath effects as a mobile remote unit is moved around a specific site. Omnipoint and its customers have recorded instantaneous fades of 45dB which are not picked up by traditional averaging signal strength measurement techniques. The nature of the amplitude of RF signals and their variance has been studied in other published reports, and Omnipoint has undertaken studies of coherence bandwidth in this and other environments, which will reveal variance around the mean as a function of bandwidth. Additional testing with different bandwidths and modulation techniques is scheduled to continue in the near future, the results of which will be included in the supplemental report to be submitted in January or February.

1850 - 1990MHz ("1.9GHz") propagation study - Omnipoint has embarked on an ambitious study of propagation and interference characteristics of signals of varying bandwidths and modulation techniques in a variety of environments both indoors and out. Interference results were

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OMNIPOINT CORPORATION

7150 Campus Drive
Colorado Springs, CO 80920

PROGRESS REPORT

This Progress Report is submitted with respect to Omnipoint Corporation's 1850-2200MHz Experimental License KK2XCV File No. 2174-EX-PL-91.

July 8, 1992

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

This Progress Report is submitted with respect to Omnipoint Corporation's 1850-2200MHz Experimental License KK2XCV File No. 2174-EX-PL-91. The findings from the experiments conducted under this experimental license are submitted for the benefit of the Commission and the OFS and PCS community of interests. Interim Reports were submitted on June 25, 1992 with respect to this experimental license. Those results and the ones reported in this Progress Report are also being used in support of three separate pioneers preference requests for three distinct new services. These services have been described in those requests and are only summarized here as 1) PP-58: Two way, wide area, telephony and low speed data, PCS/PCN; 2) PP-59: One way, high speed, data broadcast; and 3) PP-60: Two way, asymmetric, high speed to remotes/low speed from remotes, mobile data communications. The Interim Reports regarding our experimental license were submitted with the above pioneers preference requests and reply comments. In the interests of reducing paper these will be subsumed here by reference. The remainder of this Progress Report will discuss the results of further experiments and their implications for regulatory options.

I. Importance of Defining PCS Technology Specific Exclusion Zones Around OFS Users as the Key to Introducing PCS into the 1850-2200MHz Band

As we have discussed in many earlier papers, different proposed technologies for PCS have radically different capabilities for sharing with OFS users. Some proposed PCS technologies could violate the TSB10-E standard from a single handset more than 20 miles away in any direction from an OFS receiver, while other PCS technologies could operate an entire loaded cell within less than 5 miles as long as it is outside the beampath.

Regardless of the non-sharing merits of any proposed PCS technology (eg, cost, availability, voice quality, etc), and regardless of whether a PCS proponent wants to try to buy out incumbent microwave users or coexist, the Commission will have to establish rules specifying when a PCS system is defined as causing interference to an OFS user. Under almost every proposed PCS scenario many, if not most, of the total OFS links in the U.S. will remain unaffected by new PCS services for many, many years. This is simply due to the fact that many OFS sites are many miles beyond the RF horizons of the areas where PCS services will be introduced. Nonetheless, roughly half of the OFS links are within the RF horizons of the top 300 MSAs. How many of these would have to be moved or negotiated with is a function of the specific PCS technologies proposed and the ultimate rules defining interference and coexistence.

The existing standard for defining interference to an OFS is embodied in the TSB10-E, but these rules were defined anticipating interference only from other fixed, similarly powered and modulated, highly directional, microwave transmitters. Interference from PCS sources is very different, and as we have documented in our experimental reports, varies enormously from one proposed PCS technology to another. As important, the claims for coexistence by different PCS providers are based on radically different propagation assumptions.

Statements have been made by several parties that "100Mhz of unused spectrum" exists in specific cities, or "50MHz" etc. Since this is often stated about MSAs where every frequency in the 1850-1990MHz band is already licensed, such statements are clearly assuming an ability to geographically reuse or temporally reuse these OFS frequencies. Unfortunately, all of the assumptions that are being used are often not made clear.

Geographic reuse presumes some standard for propagation from PCS base stations and remotes to the incumbent OFS. It also presumes an agreement on how OFS receivers react to different kinds of interference, even when the interference is frequency offset to specific channels. Further, it presumes agreement on the characteristics and effects of cumulative interference from many fully loaded PCS cells. For narrowband PCS architectures (eg, 100KHz, 200KHZ, 500KHz, etc), a single assumption change in the propagation model can suddenly reduce "100Mhz of unused spectrum" to a specific set of noncontiguous 1 MHz slices summing to no more than 10MHz or even zero MHz in many areas.

Temporal reuse is much more problematic, and wholly unrealistic today since OFS receivers and transmitters have no intelligence in them to sense interference and change subchannels.

There are additional real world complexities to sharing introduced by variations in the actual characteristics of specific microwave links, for example: analog vs. digital, antennae height, antennae type and rejection capabilities, OFS receiver bandwidth (they vary from 10 - 28MHz), distance and fade margin.

Thus, we currently have a situation where each PCS proponent or incumbent OFS can claim either the ability to coexist or the threat of interference without any agreement on the assumptions.

Yet, despite all these apparent difficulties, it is possible to develop standards for defining interference and coexistence. The specific characteristics of every OFS link exist in computer databases and can be easily verified. The susceptibility to different types of PCS interferers can be characterized for each type of OFS receiver. Omnipoint began this process and submitted the initial results in our Interim Reports. And propagation assumptions can be brought into the light of analysis and actual field data which will allow highly conservative but realistic formulaes to be created which both OFS and PCS providers can live with.

The PCS industry as a whole has accumulated an immense amount of data which can be used over the next few months to establish rules which will define "Exclusion Zones" around OFS links which are 1) highly conservative, 2) vary by the specific characteristics of the type of OFS link, and 3) vary by the specific PCS technology proposed.

By defining these "Exclusion Zones" as technology specific, the Commission can then remove itself from the process of determining case by case territorial disputes. Moreover, PCS providers will be free to choose modulation characteristics knowing the consequences for their geographic area. Both the PCS and the OFS users will be encouraged to negotiate since they will both know the economic and operational tradeoffs of using different PCS technologies, or providing incumbents with upgraded equipment to reduce susceptibility, or the costs of negotiated settlements to remain and share or be relocated.

Propagation Assumptions

As detailed in our pioneers preference filings and replies, the Hata models used almost ubiquitously by the industry are inappropriate for determining interference conditions. The flaws are numerous -- there are six Hata models but they reflect averages rather than worst cases (eg, the handset on a roof top in a large urban city can be the equivalent of 100,000 handsets at the average location in that city), they use medians rather than means to determine the average which skews the results (by roughly 13db in the Hata Suburban case, for example), they breakdown when used for transmitters and receivers above relatively low heights and begin to give counterintuitive results (yet some microwave towers in Manhattan, for example, are at 1300 feet).

Omnipoint is developing a more detailed propagation model based on actual field data from many parties and with the purpose of estimating interference. The Hata models were not designed for measuring interference but for filling in coverage from a cellular system.

In the short term, we are testing approximations based on free space loss assumptions for the first several miles, then corrected, conservative, Hata assumptions further out, plus assumptions for interference from even beyond the RF horizon.

II. Different PCS Technologies Have Radically Different Abilities to Coexist With OFS Users

As documented thoroughly in our Interim Reports, interference to analog OFS (83% of all OFS) from PCS transmitters rises as the PCS bandwidth is reduced from 10MHz. This was confirmed in both bench and field tests. Narrowband PCS systems will require dramatically larger Exclusion Zones outside the beampaths of the OFS links. Depending on the bandwidth of the PCS system, narrowband PCS can require Exclusion Zones 20 to 100 times larger in area than a 10Mhz spread spectrum system such as Omnipoint's just from the use of a single handset.

Once the characteristics of OFS receivers are understood, the above experimental results are obvious. The reason some other parties' reports had suggested narrower PCS bandwidths were better for sharing stemmed from either misunderstandings of how OFS receivers operate, or they assumed that the power density of the PCS transmissions were the same regardless of bandwidth. In fact, a 10MHz spread spectrum signal generates 1/100th of the interference per 100KHz as a 100Khz signal, if both are at the same transmit power. (To cover the same cell area, both will be at roughly the same power since the narrowband systems will experience much more severe frequency selective fades and therefore require higher transmit powers than a raw comparison of receiver sensitivities might suggest.) Coupled with the fact that the analog OFS receivers are essentially a series of narrowband channels and down convert narrowband interference to narrowband baseband, the differences in sharing capabilities between narrowband and 10MHz PCS become readily apparent. A single 200KHz transmitter such as a GSM or DCS1800 handset can interfere with up to 50 OFS subchannels. At 100mW, it can violate the TSB10-E standard from 10 - 30 miles away depending on propagation assumptions, even 90 degrees outside the beampath of an OFS link. In our field tests, we broke the 1db threshold with a single narrowband 44mW transmitter from nearly 13 miles away and 30° outside the beampath.

We also discovered that analog OFS receivers are particularly susceptible to narrowband interference at particular frequencies. If enough narrowband interference hits a sensitive frequency, the OFS receiver becomes confused, loses its pilot signals, and all subchannels lose communication. Because the sensitive frequencies are not all obvious a priori, we are conducting more research before summarizing the findings. We hope to present these in our next progress report.

III. Cumulative PCS Interference Per Cell Varies Dramatically Among Different PCS Technologies

Perhaps the easiest way to visualize the difference between PCS systems from a cumulative interference perspective is to compare the Omnipoint system which uses CDMA, FDMA, and TDMA with a CDMA-only system. (A detailed comparison was presented in the pioneers preference requests and replies.)

CDMA-only systems aggregate interference on to the same frequency channel as each CDMA-only user comes on. For example, 100 CDMA-only users in an area (whether in one cell sector or two adjacent cell sectors) using an N=1 frequency reuse pattern will generate at least 100 times as much interference on that frequency band as 1 user. In large cells, this could be 100 times 100mW, or 10 Watts. In smaller cells, this could be 100 times 10mW, or 1 Watt. Further, if the CDMA-only system is using 1/10th the bandwidth of the Omnipoint 10MHz system, or 1MHz, the cumulative effect of multiple users in the loaded cell case will more than offset even the lower power (10mW) assumption.

As explained in our earlier filings, Omnipoint's system uses spread spectrum and coding techniques to dramatically raise the effective information rate and then uses time to separate users within a cell. Cells are separated by frequency offsets and codes. Since only one transmitter is on at a time within a cell, the maximum interference is the worst case interference from a single handset. Even the cumulative interference from an Omnipoint cell as a function of time is never more than the equivalent of one continuous transmitter. Thus, a fully loaded Omnipoint cell[1] with each user at 100mW, would never create more interference than a single user at 100mW from an Exclusion Zone perspective.

Once again, the differences in Exclusion Zone sizes around an OFS receiver, outside the beampath, are dramatic: Omnipoint's Exclusion Zones would be up to 100 times smaller under the above assumptions than even the low powered CDMA-only system outlined above.

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1. A fully loaded Omnipoint cell could eventually have between 250-300 simultaneous voice users depending on the speech coding rate, though currently single base stations are being designed to handle less than 100 simultaneous voice users.

Modeling A Fully Loaded PCS System in a Heavy OFS Usage Region

In Omnipoint Communication's proposed two way, telephony based, PCS pioneers preference request, we specified the northern New Jersey area (or Boston, or a similar area as deemed appropriate by the Commission). The northern New Jersey area has several unique characteristics. From an OFS sharing perspective, it provides a highly realistic test for any PCS proposal. In the area under consideration, there are 78 microwave receivers either inside the 13 counties or within the RF horizon of the territory. Further, there are 23 microwave receivers within a particular area with roughly an 18 mile radius, which comprises an OFS hot spot.

Omnipoint submitted its system for analysis by two independent consulting firms -- Comsearch and Impulse Communications. According to their databases and analysis of every U.S. continental OFS link, there are only 6 MSAs out of the top 300 MSAs which have more microwave links then the area Omnipoint selected for testing. (Using a different criteria, there could be up to 15 MSAs with more links, but in either case the area is a good representative of the problem of sharing PCS with OFS).

Because of filing time constraints, we were unable to fully develop our own propagation formulae in time to replace the standard assumptions available in their computer models. Instead, we had them model the defined geographic area using our system and three different propagation assumptions: 1) Hata Suburban, to establish a base case comparison to other models they had run; 2) Hata Suburban less 13db (ie, requiring much greater exclusion zones since the PCS signals propagate further to the OFS) to compensate for the Hata skew due to using medians rather than means; and 3) Free Space loss to the horizon from every handset and base station channel. We further had them assume that <u>beyond the horizon</u> interference from PCS to OFS continued at the high assumption of R=4 minus 13db just to be conservative.

All 78 microwave receivers were modeled using their exact characteristics for location, position, path distance, antennae height, antennae type and rejection capability, effective power, whether analog or digital, receiver filter bandwidth, etc. The Omnipoint system assumed every cell in the entire region was loaded to full capacity. For comparison purposes, we had Impulse run their modified DCS1800 system in the same northern New Jersey territory using the same propagation assumptions. (Note that Impulse assumes that the DCS1800 equipment is modified to use Time Division Duplexing so that it can take advantage of any 200KHz contiguous slice that shows up as noninterfering to the OFS. Obviously the actual DCS1800 could not do this. Omnipoint's existing 1850-2200MHz pocket phones and base stations, on the other hand, can already use Time Division Duplexing, or can be coupled with Frequency Division Duplexing.)

Omnipoint considers this analysis to be a first pass at comparative modeling of different, (eg, 200KHz narrowband vs Omnipoint 10MHz) fully loaded, PCS systems and has not had direct access to the models to analyze them in detail. Omnipoint therefore makes no comment on either the assumptions used by Impulse to model the DCS1800 or the conclusions to be drawn from the results. We present this only as a first pass look at the relative degree of difficulty of sharing PCS technologies with OFS users.

The initial results show the dramatic relative difference between the two systems from the perspective of how much of the 140MHz of spectrum in the 1850-1990MHz band is available for PCS on a noninterfering basis on a cell by cell basis. Under these models' assumptions and using the Free Space Loss scenario described above, the Omnipoint system would have 50-140MHz of spectrum available in over 93% of the territory, or potentially enough to support two PCS operators. Conversely the Time Division Duplexed DCS1800 system would have less than 50MHz available in 64% of the territory. More importantly, the Omnipoint system would still have 30-50Mhz available within 90% of the OFS hot spot described above, while the modified DCS1800 system would have less than 30MHz available in that area plus the surrounding area almost twice in size.

One must be cautious in interpreting these computer models' results. Omnipoint is not saying that no microwave links would have to be relocated. We are also not advocating a pure Free Space Loss propagation assumption model, we believe the real world is more complex than this and not as bad. Free Space Loss was the simplest assumption to test to in order bound the worst case for a quick comparison of the two PCS systems. Further, without the Commission allowing the use of "flexible spectrum" for at least some period of negotiating time as recommended in our Omnipoint Communication's Reply Comments of June 25, 1992, we do not yet know if the specific 50Mhz available in certain cells would be eligible for us to use.

What this first pass analysis does show is that different PCS technologies will require radically different relocation or negotiation costs for coexisting with OFS.

Other Hardware Test

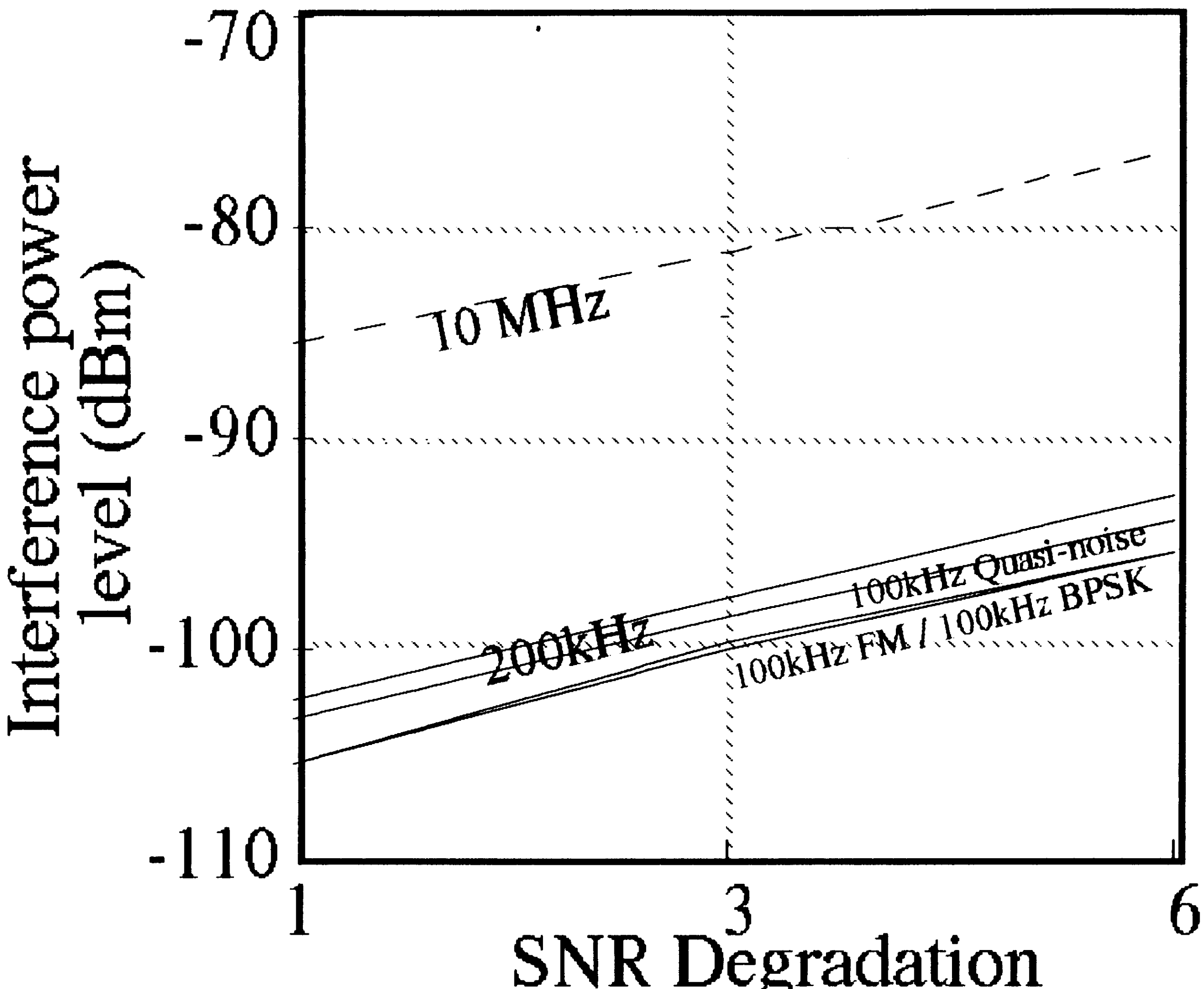
Omnipoint Communications has continued to test its pocket phones and base stations at 1850-2200MHz in different environments and with different antennaes. These results will be summarized in our August report.

Omnipoint Mobile Data Company has successfully tested a data modem operating at 512kbps in a single 10MHz channel at the 1850-220MHz frequencies. The system is frequency agile across all 14 frequencies. Since the remotes will transmit over standard existing frequencies (such as data over cellular, Ardis, RAM, etc.) there are no handsets to consider when modeling interference to OFS. Nor is there any FCC action necessary regarding the handsets' transmitters since Omnipoint Mobile Data is not asking for an allocation at these existing cellular, Ardis, RAM, etc. frequencies, but will simply make handsets which can use those industry standards. This asymmetric mobile data service could also use the frequencies from 2110-2200MHz, for transmissions from the base stations to the handsets, under consideration by the FCC if so deemed.

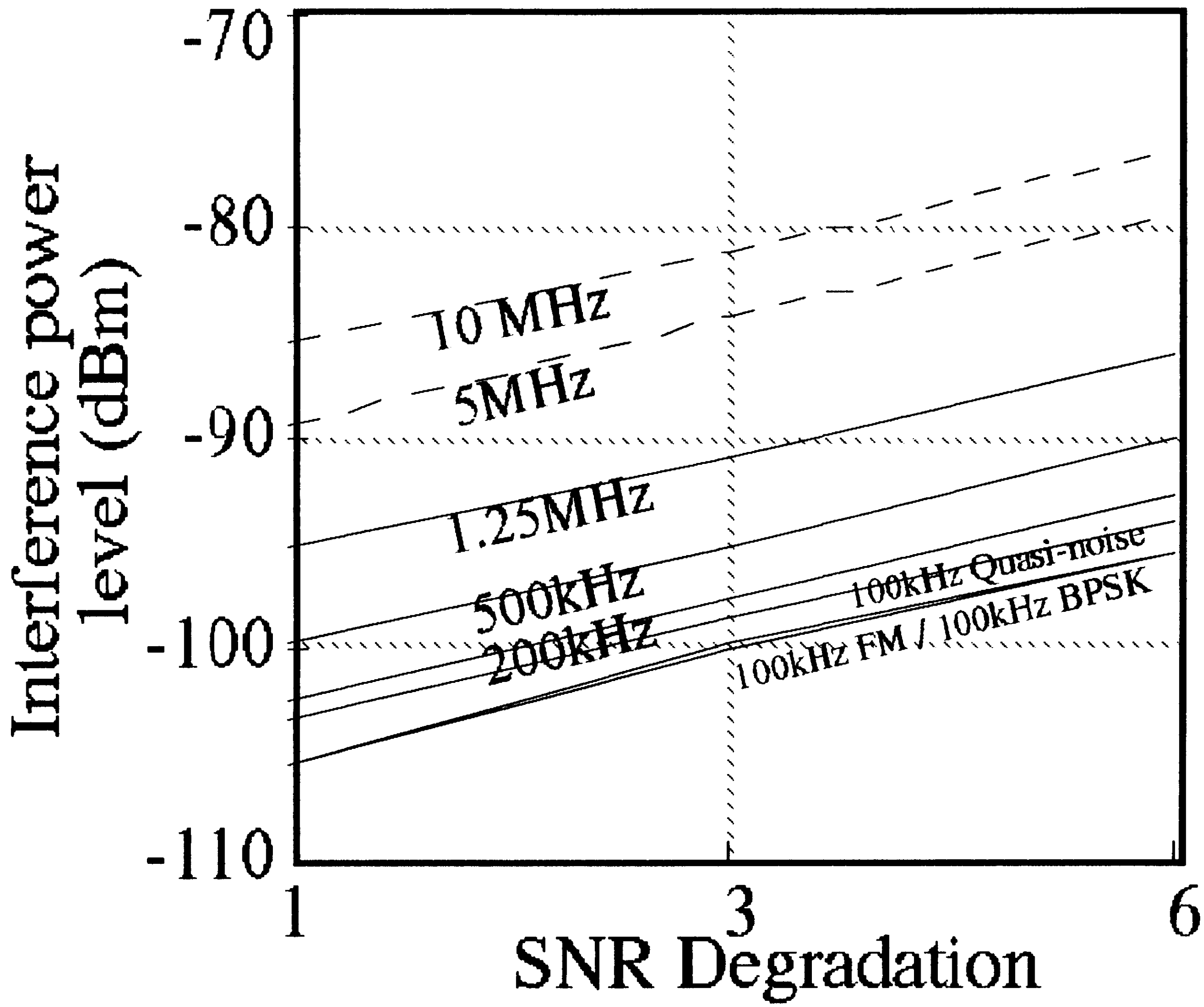
Sincerely,

Douglas G. Smith

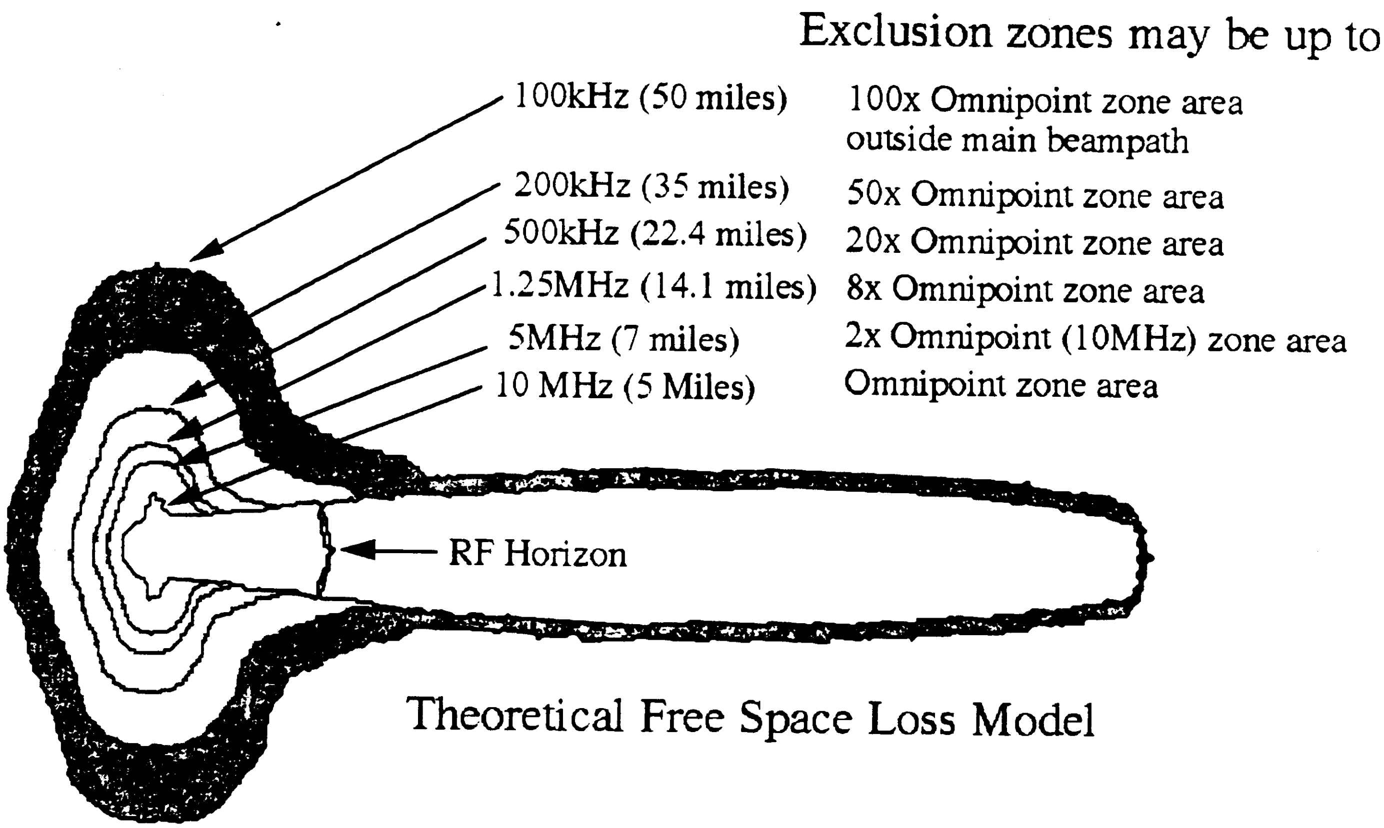
Typical OFS channel's interference susceptibility from different PCS transmitters



Typical OFS channel's interference susceptibility from different PCS transmitters



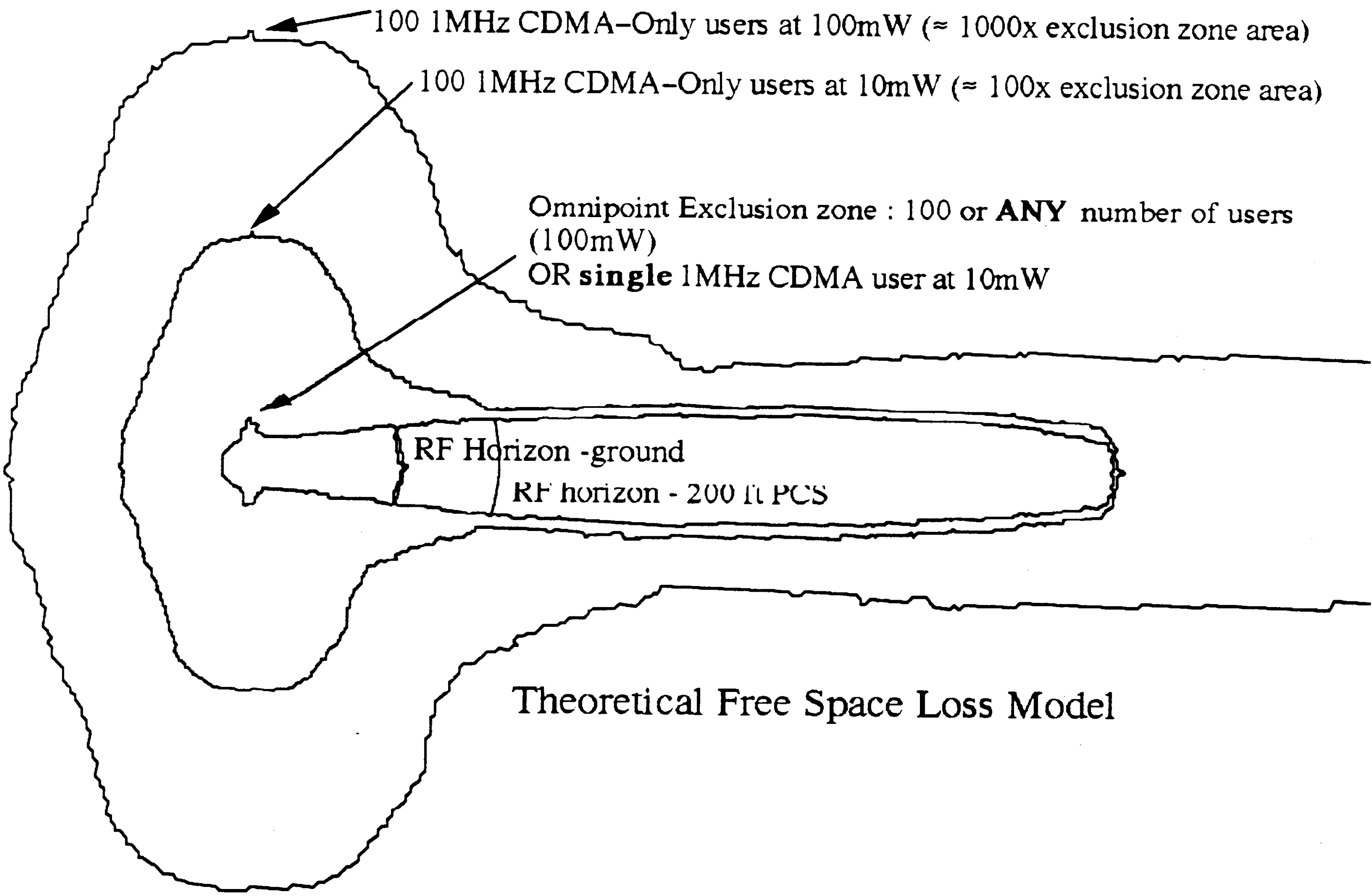
Exclusion Zones For Omnipoint Are Significantly Smaller Than For Narrowband Systems



Theoretical Free Space Loss Model

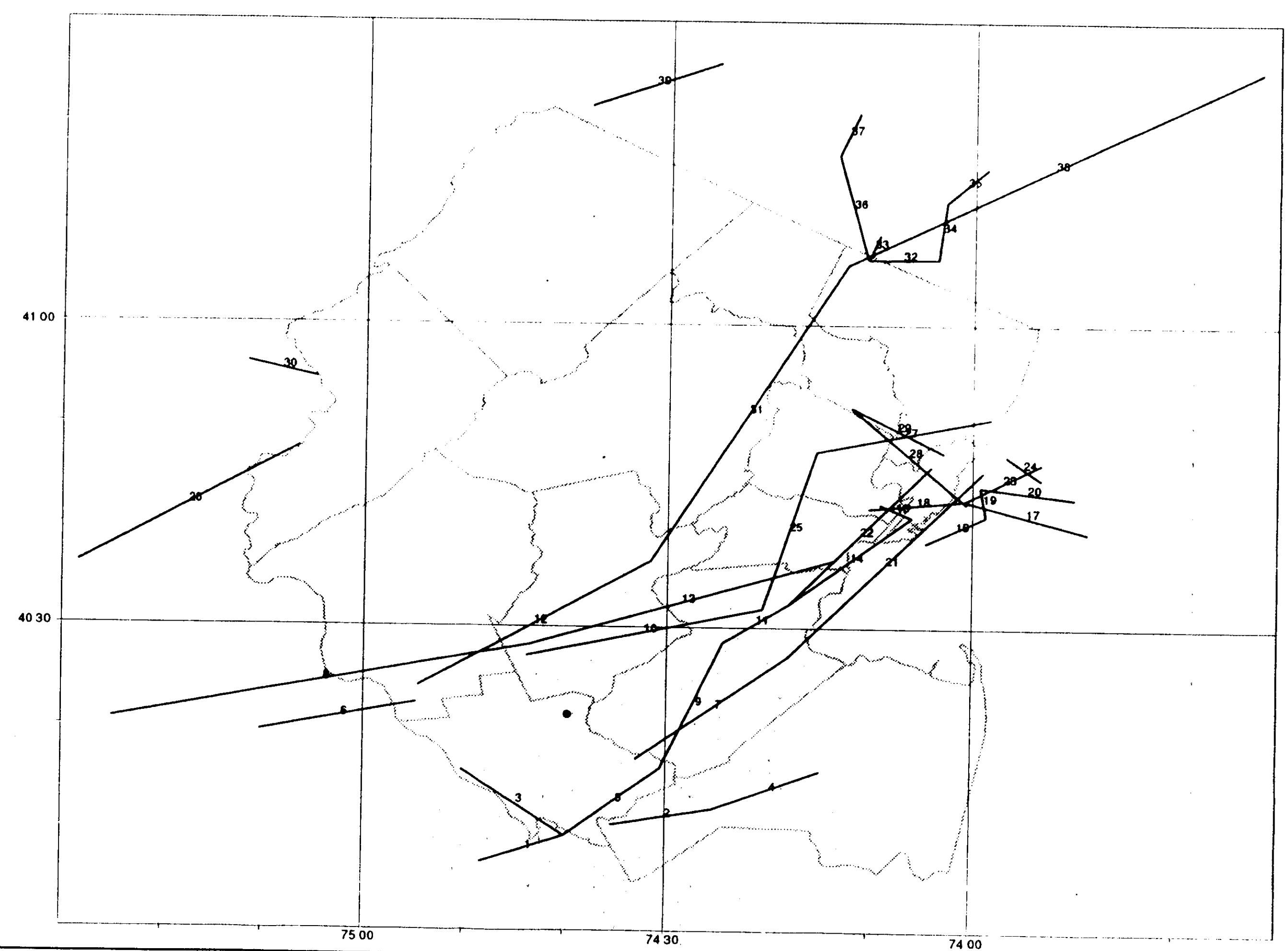
Assumptions: Both PCS devices are transmitting at 100mW using a 0dB gain, omnidirectional antenna at a height of 30 feet
2GHz microwave receiver, directional antenna at a height of 200 feet

With Multiple Users, Exclusion Zones For Omnipoint Arc Dramatically Smaller Than For CDMA-Only Systems



Assumptions: All PCS devices are transmitting using a 0dB gain, omnidirectional antenna at a height of 30 feet
2GHz microwave receiver, directional antenna at a height of 200 feet

NORTHERN NEW JERSEY
1850-1990 MHz MICROWAVE PATHS



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SYSTEM LEGEND

INPUT PARAMETERS

PCN EIRP / PT	:	-7.85 dB
BASE STATION HT	:	10 m
PCN SUBSCRIBER HT	:	2 m
CELL SIZE	:	1.609 km
PROPAGATION TO HORIZON:		FSL
PROPAGATION BEYOND HOR:		R=4 - 13

1 INCH = 21.77 MILES

1 INCH = 35.04 KM

RESOLUTION 10 sec 308 m

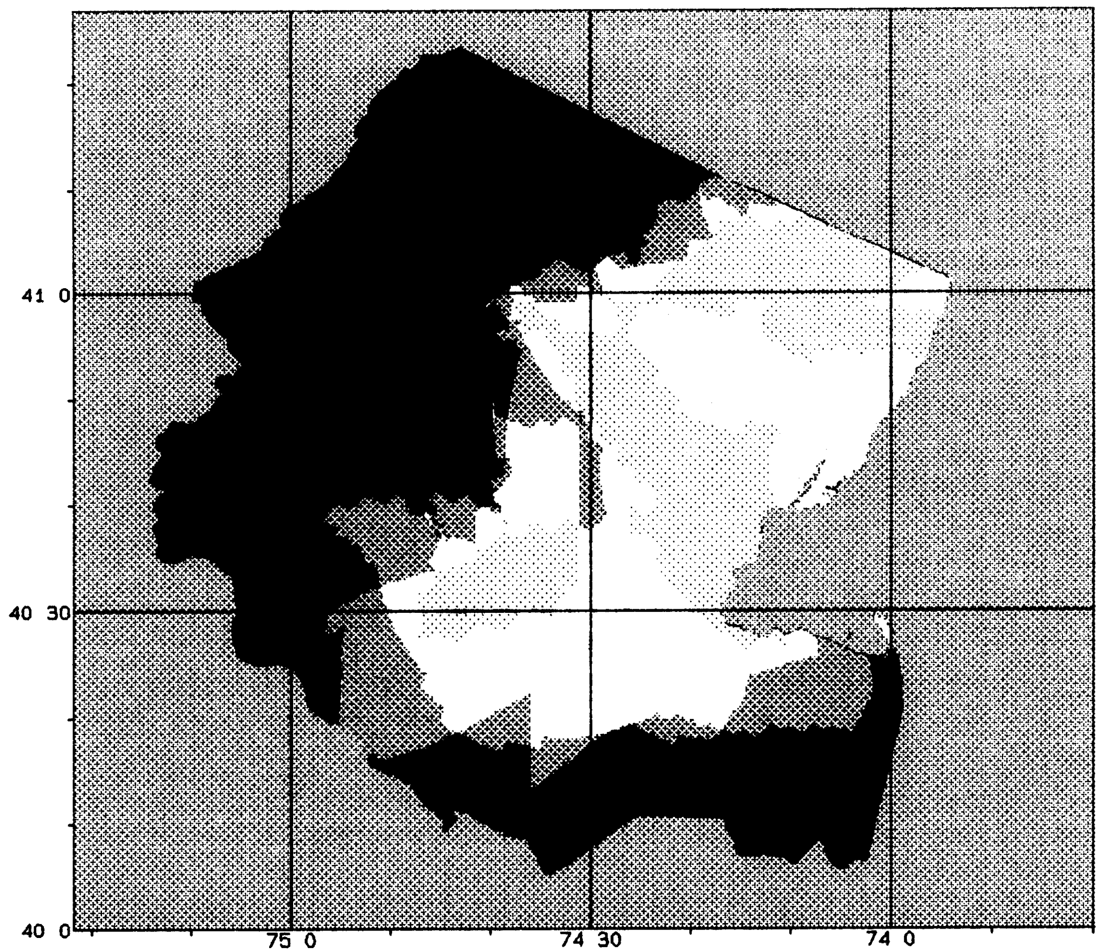
Jul 8 1992

COLOR LEGEND

- 140 MHz Available
- 51-139 MHz Available
- 41-50 MHz Available
- 31-40 MHz Available
- 21-30 MHz Available
- 11-20 MHz Available
- 1-10 MHz Available
- 0 MHz Available

NORTHERN NEW JERSEY EXCLUSION ZONE MAP

TDD DCS 1800



COMSEARCH

SPECTRUM SHARING ANALYSIS
NORTHERN NEW JERSEY AREA
July 7, 1992

OMNIPOINT TECHNOLOGY
FREE SPACE TO THE HORIZON, (R=4)-13 DB BEYOND HORIZON
TOTAL MSA SIZE — *13,226.5 SQUARE KM*

EXCLUSION ZONE	MHZ AVAILABLE	SQ AREA KM	SQ AREA MI	% OF MSA
	140	1,938.4	748.4	14.66%
	51-139	10,343.3	3,993.5	78.20%
	41-50	547.0	211.2	4.14%
	31-40	294.6	113.7	2.23%
	21-30	92.4	35.7	0.70%
	11-20	10.8	4.2	0.08%
	1-10	0.0	0.0	0.00%
	0	0.0	0.0	0.00%

INTERFERENCE ZONE	MHZ AVAILABLE	SQ AREA KM	SQ AREA MI	% OF MSA
	140	11,289.1	4,358.7	85.35%
	51-139	1,937.4	748.0	14.65%
	41-50	0.0	0.0	0.00%
	31-40	0.0	0.0	0.00%
	21-30	0.0	0.0	0.00%
	11-20	0.0	0.0	0.00%
	1-10	0.0	0.0	0.00%
	0	0.0	0.0	0.00%

COMPOSITE ZONE	MHZ AVAILABLE	SQ AREA KM	SQ AREA MI	% OF MSA
	140	1,938.3	748.4	14.65%
	51-139	10,336.8	3,991.0	78.15%
	41-50	531.9	205.4	4.02%
	31-40	310.2	119.8	2.35%
	21-30	98.5	38.0	0.74%
	11-20	10.8	4.2	0.08%
	1-10	0.0	0.0	0.00%
	0	0.0	0.0	0.00%

SYSTEM LEGEND

INPUT PARAMETERS

PCN EIRP / PT	:	-23.2 dB
BASE STATION HT	:	10 m
PCN SUBSCRIBER HT	:	2 m
CELL SIZE	:	1.609 km
PROPAGATION TO HORIZON:		FSL
PROPAGATION BEYOND HOR:		R=4 - 13

1 INCH = 21.77 MILES

1 INCH = 35.04 KM

RESOLUTION 10 sec 308 m

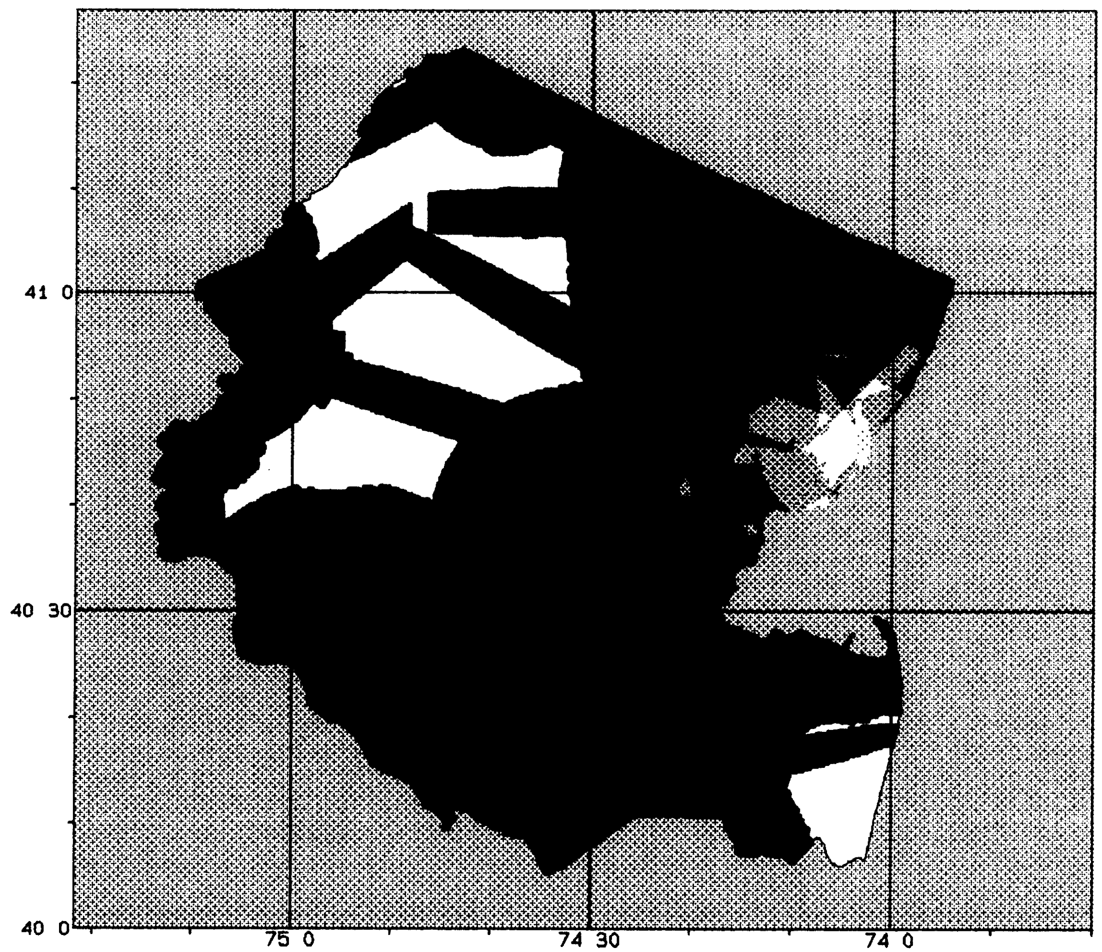
Jul 8 1992

COLOR LEGEND

- 140 MHz Available
- 51-139 MHz Available
- 41-50 MHz Available
- 31-40 MHz Available
- 21-30 MHz Available
- 11-20 MHz Available
- 1-10 MHz Available
- 0 MHz Available

NORTHERN NEW JERSEY EXCLUSION ZONE MAP

OMNIPOINT SYSTEM



COMSEARCH

MICROWAVE PATH DATA

Path: 1

	NEW JERSEY TURNPIKE AUTHORITY	
Station Name	CHESTERFIEL NJ	FLORENCE TW NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	KED45	KEG76
Latitude	40 9 18.0	40 6 38.0
Longitude	74 40 0.0	74 48 26.0
AGL/Power	147 FT / 36.0 dBM	98 FT / 36.0 dBM
Transmit Frequencies (MHz) LL/HL	1875.000H	1985.000H

Path: 2

	MONMOUTH COUNTY POLICE	
Station Name	SCHOOLHSE L NJ	HIGH ST NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WNTG424	WNTG423
Latitude	40 12 2.0	40 10 25.0
Longitude	74 25 29.0	74 35 24.0
AGL/Power	150 FT / 31.0 dBM	134 FT / 30.0 dBM
Transmit Frequencies (MHz) H2/L2	1980.000V	1900.000V

Path: 3

	NEW JERSEY TURNPIKE AUTHORITY	
Station Name	EWING TWP NJ	CHESTERFIEL NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	KED46	KED45
Latitude	40 15 45.0	40 9 18.0
Longitude	74 50 17.0	74 40 0.0
AGL/Power	147 FT / 36.0 dBM	147 FT / 36.0 dBM
Transmit Frequencies (MHz) NS/LL	1915.000V	1865.000V

Path: 4

	MONMOUTH COUNTY POLICE	
Station Name	POLICE NJ	SCHOOLHSE L NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WNE0950	WNTG424
Latitude	40 15 51.0	40 12 2.0
Longitude	74 14 46.0	74 25 29.0
AGL/Power	135 FT / 32.0 dBM	150 FT / 32.0 dBM
Transmit Frequencies (MHz) L2/H2	1890.000V	1970.000V

NEW JERSEY TURNPIKE AUTHORITY Path: 5

Station Name	WINDSOR NJ	CHESTERFIELDNJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	KEG77	KED45
Latitude	40 16 4.0	40 9 18.0
Longitude	74 30 33.0	74 40 0.0
AGL/Power	97 FT / 39.0 dBM	147 FT / 39.0 dBM
Transmit Frequencies (MHz) HL/LL	1965.000H	1885.000H

PHILADELPHIA ELECTRIC CO Path: 6

Station Name	LAMBERVILLE PA	NEW BRITAIN PA
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WNTK505	WNTA826
Latitude	40 22 24.0	40 19 33.0
Longitude	74 54 45.0	75 10 20.0
AGL/Power	75 FT / 24.0 dBM	190 FT / 24.0 dBM
Transmit Frequencies (MHz) H2/L2	1960.000H	1880.000H

MCGRAW HILL, INC. NET ENG N-1 Path: 7

Station Name	OLD BRIDGE *NJ	HIGHTSTOWN *NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WHK717	WHK716
Latitude	40 27 7.0	40 16 54.0
Longitude	74 18 4.0	74 33 3.0
AGL/Power	100 FT / 30.0 dBM	290 FT / 30.0 dBM
Transmit Frequencies (MHz) H2/L2	1980.000H	1900.000H

TRANSCONTINENTAL GAS PIPE LINE CORP Path: 8

Station Name	NESHANIC *NJ	TYLERSPORT *PA
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	KEB68	KGC96
Latitude	40 28 13.0	40 20 43.0
Longitude	74 43 36.0	75 25 7.0
AGL/Power	240 FT / 39.0 dBM	360 FT / 39.0 dBM
Transmit Frequencies (MHz) LL/HL	1865.000V	1965.000V

	NEW JERSEY TURNPIKE AUTHORITY	Path: 9
Station Name	NEW BRUNSWI NJ	WINDSOR NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	KED44	KEG77
Latitude	40 28 31.0	40 16 4.0
Longitude	74 24 28.0	74 30 33.0
AGL/Power	172 FT / 31.0 dBM	97 FT / 39.0 dBM
Transmit Frequencies (MHz) LL/HL	1865.000V	1945.000V

	PUBLIC SERVICE ELECTRIC AND GAS CO	Path: 10
Station Name	PIERSON ST NJ	SOURLAND MT NJ
Path Status	Applied	Applied
Call Sign	WNTE214	SOURLAND
Latitude	40 31 51.0	40 27 6.0
Longitude	74 20 36.0	74 43 57.0
AGL/Power	130 FT / 30.0 dBM	120 FT / 30.0 dBM
Transmit Frequencies (MHz) L2/H2	1890.000H	1970.000H

	NEW JERSEY TURNPIKE AUTHORITY	Path: 11
Station Name	WOOD BRIDGE NJ	NW BRUNSWIC NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	KBX88	KED44
Latitude	40 32 20.0	40 28 31.0
Longitude	74 18 1.0	74 24 28.0
AGL/Power	116 FT / 25.0 dBM	172 FT / 25.0 dBM
Transmit Frequencies (MHz) HL/LL	1985.000V	1905.000V

	ALGONQUIN GAS TRANSMISSION CO	Path: 12
Station Name	BOUND BROOK*NJ	LAMBERTVILL*NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WAJ80	WAH713
Latitude	40 36 32.0	40 24 1.0
Longitude	74 31 42.0	74 54 39.0
AGL/Power	120 FT / 37.0 dBM	210 FT / 37.0 dBM
Transmit Frequencies (MHz) LL/HL	1905.000H	1945.000H

Path: 13 — TRANSCONTINENTAL GAS PIPE LINE CORP

Station Name	LINDEN *NJ	NESHANIC *NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	KEB69	KEB68
Latitude	40 36 43.0	40 28 13.0
Longitude	74 13 34.0	74 43 36.0
AGL/Power	180 FT / 39.0 dBM	240 FT / 39.0 dBM
Transmit Frequencies (MHz) HL/LL	1945.000V	1855.000V

Path: 14 — NEW JERSEY TURNPIKE AUTHORITY

Station Name	BAYONNE NJ	WOODBRIDGE NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	KBX86	KBX88
Latitude	40 40 59.0	40 32 20.0
Longitude	74 5 58.0	74 18 1.0
AGL/Power	97 FT / 25.0 dBM	106 FT / 25.0 dBM
Transmit Frequencies (MHz) NS/HL	1915.000V	1975.000V

Path: 15 — CONSOLIDATED EDISON COMPANY OF NEW YORK

Station Name	HANSON PLAC NY	60 BAY ST NY
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WNEQ632	WNEQ631
Latitude	40 41 7.0	40 38 27.0
Longitude	73 58 41.0	74 4 37.0
AGL/Power	291 FT / 27.0 dBM	92 FT / 27.0 dBM
Transmit Frequencies (MHz) H2/L2	1950.000H	1870.000H

Path: 16 — NEW JERSEY TURNPIKE AUTHORITY

Station Name	NEWARK NJ	BAYONNE NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	KED42	KBX86
Latitude	40 42 18.0	40 40 59.0
Longitude	74 9 8.0	74 5 58.0
AGL/Power	32 FT / 25.0 dBM	97 FT / 25.0 dBM
Transmit Frequencies (MHz) HL/LL	1965.000V	1885.000V

MICROWAVE PATH DATA

PORT AUTHORITY OF NEW YORK & NEW JERSEY — Path: 17

Station Name	2 WORLD TRA NY	KENNEDY ARP NY
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WNEE495	WNEE498
Latitude	40 42 40.0	40 39 30.0
Longitude	74 0 49.0	73 48 36.0
AGL/Power	1380 FT / 32.0 dBM	50 FT / 32.0 dBM
Transmit Frequencies (MHz) LL/HL	1875.000V	1955.000V

PORT AUTHORITY OF NEW YORK & NEW JERSEY — Path: 18

Station Name	2 WORLD TRA NY	NEWARK ARPT NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WNEE495	WNEE497
Latitude	40 42 40.0	40 41 51.0
Longitude	74 0 49.0	74 10 15.0
AGL/Power	1380 FT / 32.0 dBM	60 FT / 32.0 dBM
Transmit Frequencies (MHz) LL/HL	1865.000H	1945.000H

CONSOLIDATED EDISON COMPANY OF NEW YORK — Path: 19

Station Name	IRVING PLACENY	HANSON PLACENY
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WNEF576	WNEQ632
Latitude	40 44 2.0	40 41 7.0
Longitude	73 59 16.0	73 58 41.0
AGL/Power	276 FT / 21.0 dBM	291 FT / 21.0 dBM
Transmit Frequencies (MHz) LL/HL	1905.000V	1985.000V

CONSOLIDATED EDISON COMPANY OF NEW YORK — Path: 20

Station Name	IRVING PLAC NY	QUEENS BLVD NY
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WNEF576	WNEF577
Latitude	40 44 2.0	40 42 54.0
Longitude	73 59 16.0	73 49 52.0
AGL/Power	276 FT / 24.0 dBM	246 FT / 24.0 dBM
Transmit Frequencies (MHz) H2/L2	1980.000V	1890.000V

	PUBLIC SERVICE ELECTRIC AND GAS CO	Path: 25
Station Name	WEST ORANGE NJ	PIERSON ST NJ
Path Status	Applied	Applied
Call Sign	WESTOR	WNTE214
Latitude	40 47 26.0	40 31 51.0
Longitude	74 15 24.0	74 20 36.0
AGL/Power	145 FT / 29.0 dBM	130 FT / 29.0 dBM
Transmit Frequencies (MHz) H2/L2	1960.000H	1880.000H

	PENNSYLVANIA POWER & LIGHT CO	Path: 26
Station Name	MARTINS CRK PA	ALLENTOWN PA
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	KGL42	KGL41
Latitude	40 47 43.0	40 36 7.0
Longitude	75 6 31.0	75 28 33.0
AGL/Power	350 FT / 37.0 dBM	285 FT / 37.0 dBM
Transmit Frequencies (MHz) LL/LL	1905.000V	1855.000V

	PUBLIC SERVICE ELECTRIC AND GAS CO	Path: 27
Station Name	PALISADE AV NJ	WEST ORANGE NJ
Path Status	Applied	Applied
Call Sign	PALISADE	WESTOR
Latitude	40 50 48.0	40 47 26.0
Longitude	73 58 11.0	74 15 24.0
AGL/Power	320 FT / 20.0 dBM	105 FT / 20.0 dBM
Transmit Frequencies (MHz) L2/H2	1860.000V	1940.000V

	CITIBANK NA	Path: 28
Station Name	CLOVE RD NJ	20 EXCHANGE NY
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WNEE420	WED756
Latitude	40 51 53.0	40 42 19.0
Longitude	74 12 3.0	74 0 35.0
AGL/Power	250 FT / 28.0 dBM	728 FT / 28.0 dBM
Transmit Frequencies (MHz) HL/LL	1975.000H	1895.000H

	CITIBANK NA	Path: 29
Station Name	CLOVE RD NJ	H MEADOW BV NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WNEE420	WNEV799
Latitude	40 51 53.0	40 47 21.0
Longitude	74 12 3.0	74 2 49.0
AGL/Power	200 FT / 20.0 dBM	80 FT / 20.0 dBM
Transmit Frequencies (MHz) H2/L2	1950.000V	1870.000V

	METROPOLITAN EDISON CO	Path: 30
Station Name	FOX GAP RPTRPA	PORTLAND GENPA
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WIW91	WIW92
Latitude	40 56 6.0	40 54 33.0
Longitude	75 11 49.0	75 4 47.0
AGL/Power	105 FT / 33.0 dBM	150 FT / 33.0 dBM
Transmit Frequencies (MHz) LL/HL	1905.000V	1955.000V

	ALGONQUIN GAS TRANSMISSION CO	Path: 31
Station Name	MAHWAH *NJ	BOUND BROOK*NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	KWB44	WAJ80
Latitude	41 6 0.0	40 36 32.0
Longitude	74 12 26.0	74 31 42.0
AGL/Power	335 FT / 37.0 dBM	120 FT / 37.0 dBM
Transmit Frequencies (MHz) HL/L2	1935.000H	1860.000H

	ORANGE AND ROCKLAND UTILITIES INC	Path: 32
Station Name	SPRING VLY *NY	MAHWAH *NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WAA718	WAA716
Latitude	41 6 34.0	41 6 32.0
Longitude	74 3 36.0	74 10 29.0
AGL/Power	127 FT / 36.0 dBM	95 FT / 36.0 dBM
Transmit Frequencies (MHz) HL/LL	1935.000H	1855.000H

ORANGE AND ROCKLAND UTILITIES INC — Path: 33

Station Name	RAMAPO *NY	MAHWAH *NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WAA717	WAA716
Latitude	41 9 0.0	41 6 32.0
Longitude	74 9 20.0	74 10 29.0
AGL/Power	55 FT / 36.0 dBM	55 FT / 36.0 dBM
Transmit Frequencies (MHz) HL/LL	1955.000H	1875.000H

ORANGE AND ROCKLAND UTILITIES INC — Path: 34

Station Name	THIELS *NY	SPRING VLY *NY
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WAA719	WAA718
Latitude	41 12 15.0	41 6 34.0
Longitude	74 2 49.0	74 3 36.0
AGL/Power	25 FT / 36.0 dBM	127 FT / 36.0 dBM
Transmit Frequencies (MHz) LL/HL	1895.000H	1975.000H

ORANGE AND ROCKLAND UTILITIES INC — Path: 35

Station Name	LOVETT *NY	THIELS *NY
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WAA721	WAA719
Latitude	41 15 36.0	41 12 15.0
Longitude	73 58 45.0	74 2 49.0
AGL/Power	240 FT / 30.0 dBM	57 FT / 24.0 dBM
Transmit Frequencies (MHz) HL/LL	1935.000V	1855.000V

ORANGE AND ROCKLAND UTILITIES INC — Path: 36

Station Name	MONROE *NY	MAHWAH *NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WAA714	WAA716
Latitude	41 16 52.0	41 6 32.0
Longitude	74 13 26.0	74 10 29.0
AGL/Power	112 FT / 36.0 dBM	97 FT / 36.0 dBM
Transmit Frequencies (MHz) HL/LL	1975.000V	1895.000V

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MICROWAVE PATH DATA

ORANGE AND ROCKLAND UTILITIES INC — Path: 37

Station Name	BLOOMING GR*NY	MONROE *NY
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WAA715	WAA714
Latitude	41 21 3.0	41 16 52.0
Longitude	74 11 26.0	74 13 26.0
AGL/Power	110 FT / 36.0 dBM	152 FT / 36.0 dBM
Transmit Frequencies (MHz) LL/HL	1855.000V	1935.000V

ALGONQUIN GAS TRANSMISSION CO — Path: 38

Station Name	DANBURY *CT	MAHWAH *NJ
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	KWB53	KWB44
Latitude	41 25 17.0	41 6 0.0
Longitude	73 31 44.0	74 12 26.0
AGL/Power	130 FT / 37.0 dBM	335 FT / 37.0 dBM
Transmit Frequencies (MHz) LL/HL	1885.000H	1945.000H

ORANGE AND ROCKLAND UTILITIES INC — Path: 39

Station Name	MIDDLETOWN *NY	GREENVILLE *NY
Path Status	Licensed by FCC	Licensed by FCC
Call Sign	WAJ98	WAJ99
Latitude	41 25 55.0	41 21 37.0
Longitude	74 25 10.0	74 38 4.0
AGL/Power	155 FT / 36.0 dBM	65 FT / 36.0 dBM
Transmit Frequencies (MHz) LL/HL	1895.000V	1975.000V

Prepared by Business Information Services Division
COMSEARCH * 251 West Renner Road * Richardson Texas 75080 * (214)680-1000